Standard

Infrastructure - Signals – Design Construction and Maintenance Standard

Doc. No.: CE-021-ST-0038
Version: 1
Date: 20/03/2020

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PROUD OPERATOR OF yarra trams

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1 PURPOSE

The purposes of this standard are to specify the minimum requirements for:

- function and performance applicable to design and installation of tram signal systems, and
- equipment and marking layouts to be implemented for new and replacement signals and controllers on the network.

2 SCOPE

The scope of this standard is all requirements for the function, performance of tram signals controlled by Yarra Trams. Tram signals are those systems and associated equipment that includes auto point controllers, aspect signal (lanterns), stud and location marks used on the Melbourne Metropolitan Tram Network (MMTN) for the control of the movement of trams. Tram signals equipment includes assets that provide the status of track points; and signalised mechanisms and control systems for safe movement of trams at junctions, termini, crossovers and depots.

This standard shall apply to the design and installation requirements for the control of tram movements, using tram signals including; auto point controllers, lanterns, stud, location markings and associated infrastructure. It shall apply to all tram vehicular movements regardless of the class of vehicle.

This standard shall be used by Yarra Trams and any Consultants or Contractors working for Yarra Trams for the design and installation requirements for the control of tram movements, including auto point controllers, tram signals, lanterns, stud, location markings and associated infrastructure.

3 COMPLIANCE

This standard shall be fully complied with. Deviation from this standard is only permitted when a waiver has been sought and approved by Yarra Trams.

Shall' statements are mandatory in the context of compliance with requirements stipulated in this standard.

'Should' statements are considerations in the context of compliance with requirements stipulated in this standard.

'Information' statements provide additional content for clarification purposes only and are not requirements in the context of compliance with this standard.

'So far as is reasonably practicable' statements must at a minimum result in the provision of a technical risk assessment including proposed list of design controls to demonstrate compliance to this standard.

The design and review process shall be managed in accordance with the Yarra Trams 'Manage Design' procedure.

The design process requires consideration of design constructability, Safety in Design, RAM, Human Factors, design sustainability, single design platform, security in design, design competency and all relevant statutory requirements.

Any third party or contractor undertaking activities related to the tram signal systems (including auto point controllers), aspect signal (lanterns), stud and location marks used on the Yarra Trams network shall

complete and return a compliance schedule for this standard. Assessment of compliance shall be provided for each requirement, defined by one of three permissible responses:

- Compliant;
- Partially Compliant;
- Non-Compliant.

4 REQUIREMENTS

4.1 Track points systems used for signalling

Information: In relation to operation of signalling systems in use on the Melbourne Metropolitan Tram Network (MMTN) it is important to recognise that the system operate mainly by "line of sight" (or "sight distance driving"). Signals controlled by Yarra Trams are used at Points.

The main applications of point mechanisms in the MMTN are:

- Manual Facing Points,
- Trailing Points,
- Springloaded Points,
- Special Points and
- Automatic Points

Definitions of Sight Distance is in accordance with VicRoads Traffic Engineering Manual Vols 1, 2 and 3 along with VicRoads Supplement to the Austroads Guide to Road Design Part 4 – Intersections & Crossings – General.

Table 1 - Point application and typical locations used in the MMTN

Points Application	Typical Point Location in the MMTN
Junction Manual Facing Points Junction Trailing Points Junction Springloaded Points Junction Automatic Points	Junction Points
Terminus Manual Facing Points Terminus Trailing Points Terminus Springloaded Points Terminus Automatic Points	Terminus Points
Crossover Manual Facing Points Crossover Springloaded Points	Crossover Points
Depot Manual Facing Points Depot Trailing Points Depot Springloaded Points Depot Automatic Points	Depot Points

4.1.1 Signal Observance

4.1.1.1 Signals, signs and markers shall be clearly visible to drivers whilst in control of the vehicle.

4.1.1.2 Points shall be defined by their functional application and their location such as a Junction, Terminus, Crossover or Depot.

4.1.2 Manual Facing Points

Information: Manual Facing Points are manually operated facing points system. They require the use of a points bar to manually move the points blades. Facing points system enables trams to diverge onto different tracks. The tram movement is such that the tram approaches the points facing the tip of the points blades.

4.1.2.1 Manual Facing Points shall be defined as manually operated facing points system.

4.1.2.2 They shall only be operated using a points bar to manually move the points blades.

Information: There are three types of interconnecting mechanisms within the manual facing points equipment currently used in Yarra Trams' in the Melbourne network these are:

- A Series (known as 1st Generation)
- Inergron (known as 2nd Generation)
- Prazska (known as 3rd Generation)

4.1.2.3 The Prazska operating mechanism shall be used in the design and installation of new Manual Facing Points or the replacement of the "A Series" interconnecting mechanisms on Yarra Trams' Melbourne network.

4.1.2.4 The design for the installation of new "Mainline Manual Facing Points" shall incorporate signal lanterns that comply with the Yarra Trams' "Tram Signal Lantern Standard" SIG – 001-1.0-2017. The exception is at crossovers.

4.1.2.5 All track and stud marks incorporated with the design and installation of new manual facing points or the replacement of the A series interconnecting mechanisms with Prazska series mechanism shall comply with Section 4.5 Track and Stud Marks of this Standard.

4.1.3 Trailing Points

Information: Trailing Points enable trams to converge onto a single track. The movement of the tram over the points moves the points blades, therefore, they do not need a points bar. Pictorially, a tram travelling from one of the top arms of the letter "Y" onto the bottom section of the letter "Y". The tram movement is such that the tram approaches the points facing the heel of the points blades. Sometimes trailing points may be automated.

4.1.3.1 The design for the installation of new "Trailing Points" shall incorporate the Prazska series mechanism.

4.1.3.2 All track and stud marks incorporated with the design and installation of new trailing points shall comply with Section 4.5 Track and Stud Marks of this Standard.

4.1.3.3 45.7 metres is and shall remain as the standard length for trailing points. Exceptions are "Special Points" see section 4.2.5.

4.1.4 Spring-loaded Points

Information: Points system that are spring loaded with the blade held in the set position by spring pressure. Springloaded points automatically return to their set position when trailed by tram wheels.

4.1.4.1 The design for the installation of new Spring-loaded Points shall incorporate the Prazska series mechanism.

4.1.4.2 The design for the installation of new spring-loaded points shall incorporate Signal Lanterns that comply with the Yarra Trams' "Tram Signal Lantern Standard" SIG – 001-1.0-2017.

4.1.4.3 All track and stud marks incorporated with the design and installation of new Spring-loaded Points shall comply with Section 4.5 Track and Stud Marks of this Standard.

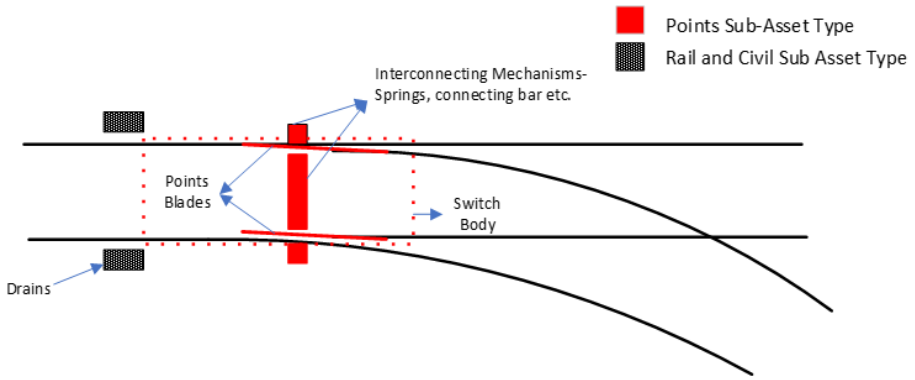


Figure 1 - Manual Facing Points, Springloaded Points and Trailing Points

4.1.5 Special Points:

Information: Certain locations on the network have points that have complex configuration, unusual operation or geometry. These are called special points and have been included only for the case of completeness. This can include:

- 47 metre points.
- points that have less than 2 metres tangent leading into the switch.
- newly introduced point types.
- back to back points.
- bi-directional points.
- points used predominantly only in one-direction facing.
- points that are predominantly used in one-direction, but may be used bi-directionally, excluding crossovers.

4.1.5.1 47 Metre Points

4.1.5.1.1 The term "Gauntlet Point" shall no longer be used and these points shall be known as 47 metre points. There are no special signalling processes used at 47 metre points. Please refer to sections 4.4 for Aspect Lanterns and 4.6 Track Stud and Location Marks.

4.1.6 Automatic Points

Information: Automatic Points are operated by a Roadbox (side mount motor or centre mount motor) that is part of the Signals Asset Class.

4.1.6.1 For side mount motor points, the equipment within Automatic Points shall include points blades, interconnecting blade mechanisms and the switch body.

4.1.6.2 For centre mount motors the interconnecting mechanisms shall be included in the Roadbox.

4.1.6.3 Automatic Points shall operate when the signalling system receives a command from the tram or signaling control system and drives the motor that switches the blades.

Information: In general, automatic points are facing points that enable trams to diverge onto different tracks. Pictorially, a tram travelling onto one of the arms of the letter "Y". A small number of points in the tram system are also automated for trailing to prevent damage to the motor mechanisms.

Most termini automatic points are typically for facing direction, while some are also for trailing.

There are two suppliers of automatic point systems used on the Melbourne network they are:

- Hanning and Kahl
- Elektroline

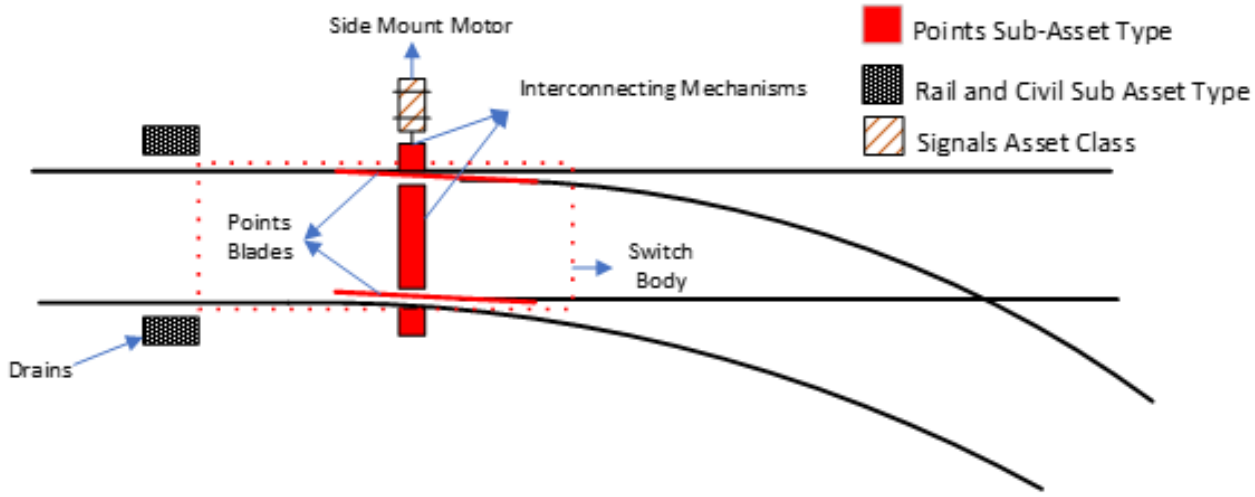


Figure 2 - Automatic Points Side-mount Motor Configuration typical of Hanning and Kahl

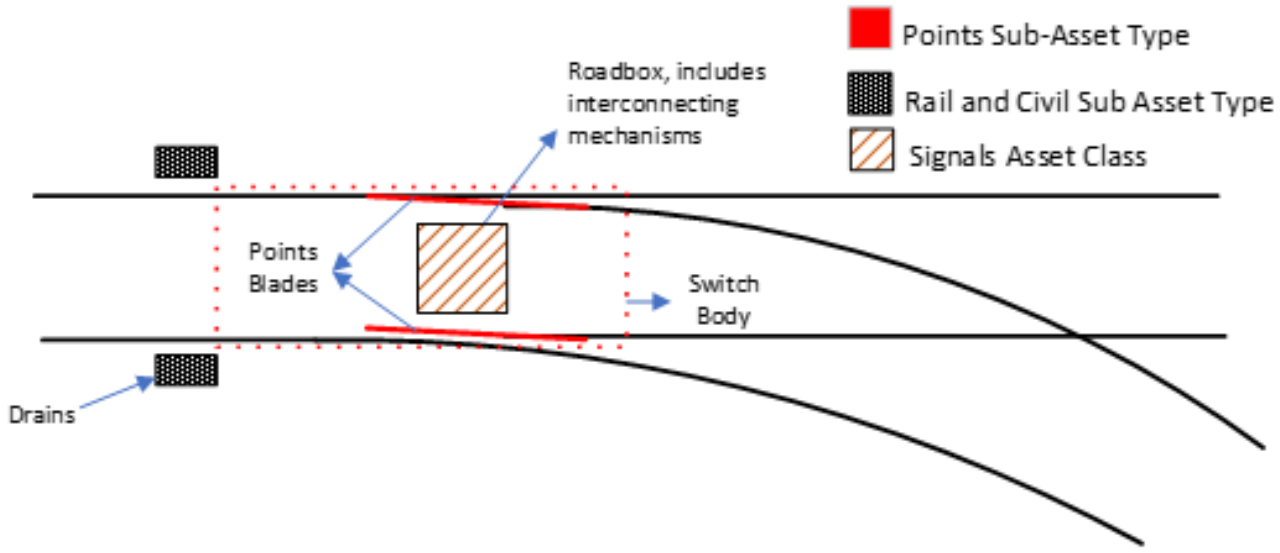


Figure 3 - Automatic Points Centre-mount Motor Configuration typical of Elektroline

Information: The following drawing are illustrative only and configurations will vary due to the location and surrounding environment.

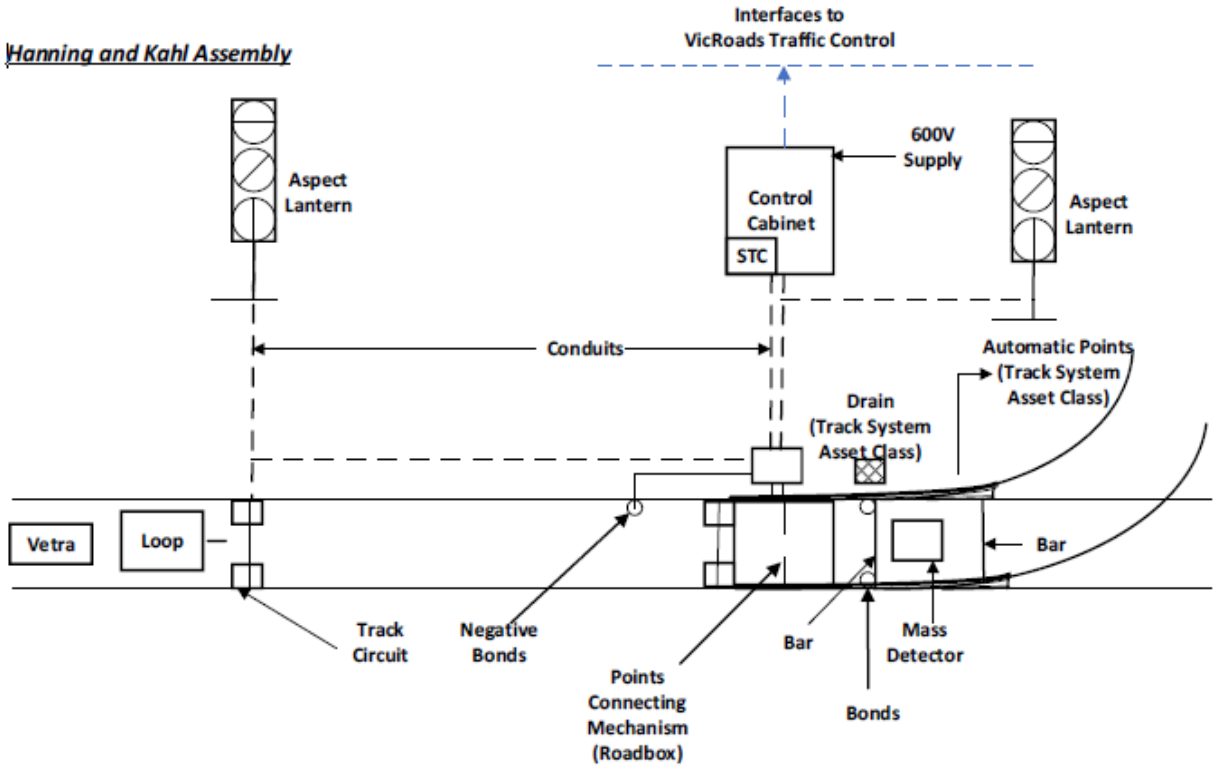


Figure 4 - Typical Hanning and Kahl Automatic Point System

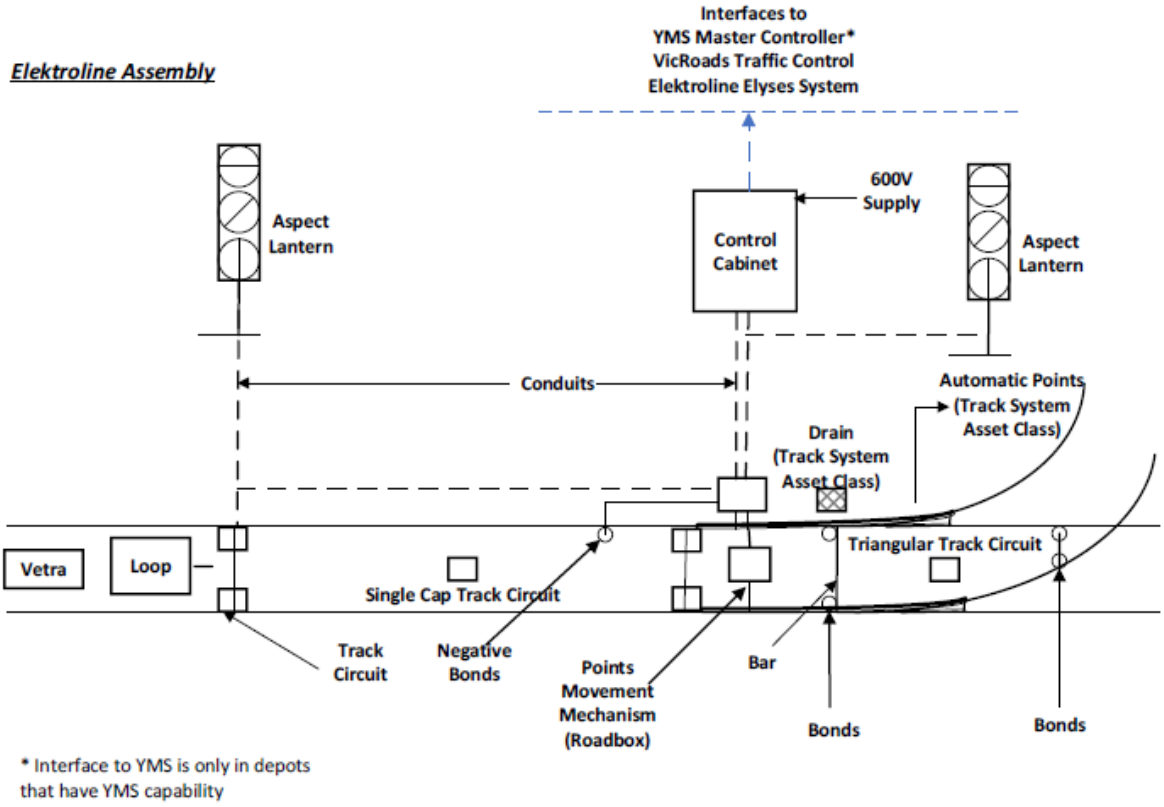


Figure 5 - Typical Elektroline Automatic Point System

4.1.6.4 All new automatic points at new track sites shall be the Elektroline Automatic Point Control System. The control system shall incorporate the Vetra Detection System.

4.1.6.5 All Automatic Points shall be able to be moved manually by points bar but shall have for provision for locking to prevent unauthorized movements.

Information: In some cases, the signalling system is part of a more complex Yard Management System (YMS). The individual points controllers within the control cabinet interface with the yard management system (YMS) master. This system may in turn communicate with corporate enterprise systems.

4.1.7 Tram Signalling Controller (Electronic control system)

Information: A Tram Signalling Controller is an electronic control system that controls electrical and mechanical assemblies and systems that interface with the track points to enable automated movement of the track points. It provides signalised mechanisms and controls for safe movement of trams in and out of terminus, depots, and through road intersections. The Points Control System is part of the Tram Signalling Controller. It is a subsystem used to select and provide signalised indication of points' status.

One of the key features of any Tram Signalling Controller that switches track points is the necessity to prohibit unwanted switching.

4.1.7.1 All Automatic Point Controllers (including ancillaries) used by Yarra Trams shall comply with Yarra Trams' – Tram Signal Controller Standard Document Number SIG – 002 – 1.0 –2017.

4.1.7.2 The track points shall be immediately blocked by the microprocessor control unit after the switching of points, after the crossing of a switching point (receiver) or after receipt of a signalling system access command.

4.1.7.3 The second additional blocking shall be independent of the functionality of the tram and of the work of the tram driver (pursuant to IEC 65 A (Sec) 123, VDV and DIN V VDE 0801 regulations these are superseded by IEC 61508, ISO/IEC 17065 and BOStrab regulations), is achieved by rail blocking resonant circuits located near each set of points.

4.1.7.4 The automatic point controller shall be configurable as a 2-way or 3-way point controller. (For single or tandem switch configurations).

Information: A signalling system controller controls combinations of points switches and tram signal aspect lanterns to allow the tram to pass or to stop through track junctions and conflict points. Signalling System Controllers may also rely on elements of "Line of Sight" operation.

4.1.7.5 Signalling system controllers shall be required to protect against operation of the points when the tram is immediately over the points mechanism.

4.1.7.6 The Tram Signalling Controller shall:

- Have minimum 16 programmable input signals available,
- Have minimum 10 programmable outputs, and
- Record all input and output contact events .

4.1.7.7 For large controllers additional inputs and outputs may be required. The Tram Signalling Controller shall have additional capability for 25% additional inputs and 25% additional outputs for future use. These inputs and outputs shall be capable of being programmed.

4.1.7.8 All tram signalling controllers shall be housed in supplied manufacturers cabinets and shall comply with Standard Drawing Automatic Points Equipment Cubicle and Concrete Base, Drawing Number STD_3005. They are sealed against water and to some extent dust ingress.

4.1.7.9 The signalling equipment cabinet shall be constructed in such a manner as "practicable as possible" to prevent accidental ingress or malicious access.

4.1.7.10 All new tram signalling controllers, used with Elektroline Automatic Points shall be Elektroline microprocessor-based controllers.

4.1.7.11 A Hanning and Kahl Microprocessor Based Controller shall only be replaced if required with a Hanning and Kahl automatic point (side motor) system as part of a maintenance practice, not as part of a new design.

4.1.7.12 At automatic points the tram signalling controller shall detect the Point Bar when a point bar is used to change to point position manually by an operator. The controller shall inhibit motor operation when the points are being operated manually to prevent operator injury.

4.1.8 Route selection command

4.1.8.1 The Tram Signalling Controller shall have capabilities to receive an input (Route selection command) from an external control device for route selection. Route detection must be covered under event recording as well as the tram identification.

4.1.9 Track Circuit, Transponder and Mass Detector

4.1.9.1 The tram mounted Transponder shall be able to be detected by a detector loop in the tramway subsurface. The track circuit interfaces to the Tram Signalling Controller and in turn the points control system.

4.1.9.2 The points control system shall be used to select the direction of the vehicle at tram track junctions.

4.1.9.3 A mass detector shall be used to detect the tram as it passes over the points. It shall detect that the tram has passed and cleared the automatic points. Further electrical switching of points shall be possible only after the tram has passed through the entire monitored area and after all protection blocking circuits have been unblocked.

Information: Melbourne's tram system operates many automatic points systems and a number of depot and track shunting systems. Most of these systems operate using conventional track circuit shunting systems combined with mass detectors to detect when the Vehicle is over the points mechanism. The system name Frequencies are as follows:

- Track Circuit Hanning and Kahl HFP, 7 to 13 kHz
- Track Circuit Hanning and Kahl HSK, 20 to 30 kHz
- Track Circuit Elektroline BOV, 20 to 30 kHz
- Mass Detector Hanning and Kahl HFK, 45 to 50 kHz
- Tram Transponder AWA Transitag System, 50 kHz

4.1.9.4 The transponders shall be mounted on vehicles, above track centre at approximately 300mm above rail level and 750 mm from the ends of the Vehicle.

4.1.10 SIL Safety Levels

Information: As a general principle all modern Tram Signal Controller applications for Mainline Operation will be integrated for SIL 3 safety levels.

4.1.10.1 Tram Signal Controller applications for Depots and Low speed operating environments shall be SIL 3 where practicable. However, it shall be acceptable at a SIL 2 level where complexity prevents the application of a SIL 3 level.

Information: As an example, single points controllers used in depots should be SIL 3 if only used in one direction. However, if it is necessary to trail the points then SIL 2 will be acceptable to prohibit the complexity (and possible damage) resulting from trailing SIL 3 motors.

4.1.10.2 SIL 3 safety levels shall requires the installation of at least two independent tram detection systems. These shall include resonant track circuits, mass detectors or combinations of both within the switch point area.

4.1.10.3 When any of the tram detection systems on the track is occupied by a tram, it shall be impossible to move the switch points electrically.

4.1.10.4 Safety of the SIL 3 system shall be assessed for SIL 3 safety integrity level by an independent assessor according to the EN 61508 standard. This has been superseded by IEC 61508-2.

4.1.10.5 For the system to be fully SIL 3 compliant the Control System shall be used in conjunction with SIL 3-point machines.

Information: Exemptions to the above are the standards for all controlled traffic lanterns, these are managed by Vic Roads in accordance with standard road intersection design practices and VicRoads Traffic Engineering manual Vol 1, 2 and 3. This process recognizes the need for integration of Light Rail Vehicles into shared roadway environments and reinforces the complementary dependency on "Line of Sight" operation.

4.1.11 Remote Communication

4.1.11.1 The Tram Signalling Controller shall have the following communication capabilities via 3G Network or via Ethernet port (RJ45) using a secure network connection.

- Short message service (SMS) communication of system status in case of any failure.
- Event data record extract.
- Remote upload and download of system configuration.
- Live system Monitoring.

4.1.11.2 The equipment shall be 4G compatible.

4.1.11.3 The controller shall be capable of remote monitoring allowing access to real time system operation, event recorder data and system diagnostics

4.1.11.4 The Controller must be capable or recording data to a remote server for the purpose of secure data capture and analysis in a non-hostile environment.

4.1.11.5 The equipment must also be designed and capable of local area network connection using either ethernet or fibre optic connection.

4.1.12 Interface with VicRoads Traffic Lights

4.1.12.1 The tram signalling controller shall have the capability to interface with the VicRoads Traffic Control Network. (See VicRoads Traffic Engineering manual Vols 1, 2 and 3)

4.1.12.2 The Tram Signalling Controller shall have at least 3 separate (Straight, Left and Right) independent traffic light outputs (Normally Open) to interface with Vic Roads controllers. This separate output does not count in the minimum 10 available outputs.

4.1.12.3 The separate independent traffic light output shall be energised by the tram selecting the direction of travel and occupying the track circuit and shall be De-energised when the tram frees the last track circuit.

4.1.13 Power Supply

4.1.13.1 The tram signalling controller be provided with an operating voltage of 24Vdc.

4.1.13.2 The operating voltage of 24Vdc shall be provided via a DC-to-DC converter from the 600Vdc traction environment.

4.1.13.3 The power supply shall have an over/under voltage protection system suitable for use on a nominal 600V dc traction supply system. (In accordance with IEC standards IEC 60850 for traction supply voltages and IEC 60038 Standard Voltages).

4.1.13.4 All HV and LV cable separations shall comply with the Electricity Safety (Installations) Regulations 2009 and Yarra Trams Electrical Infrastructure Safety Rules IN-002-ST-0002 and AS/NZ 3000 Standard: Wiring Rules,

4.1.13.5 The power supply shall have an operating temperature range from 0 °C to 60°C.

4.1.13.6 The DC-DC converter (600Vdc to 24Vdc) shall be located inside the tram signalling controller cabinet.

4.1.13.7 The DC-DC converter (600Vdc to 24Vdc) shall have an output capable of driving the tram signalling controller with a minimum of 20% spare or additional load capacity.

4.1.13.8 The Output voltage of the DC – DC convertor located inside the tram signalling controller cabinet shall be linear regulated.

4.1.13.9 The tram signalling controller shall have a battery backup at least for one hour in case of main incoming power failure.

4.1.13.10 The point motors shall use the 600Vdc supply controlled via the signalling controller.

4.1.13.11 The installation of the 600Vdc supply to the tram signalling controller at automatic points shall comply with the Standard Drawing 600V Supply Pole to Autopoints Cabinet Layout Drawing Number STD_T3003 and AS/NZS 3000 Wiring Rules.

4.1.14 Bonding

4.1.14.1 Automatic points bonds shall provide the points control circuits with connectivity to the 600Vdc supply for the DC to DC converter and the points' motor and the points' motor power control.

4.1.14.2 All bonding shall comply with the Yarra Trams Bonding Application Guide – BAG_21_06_2017.

4.1.14.3 All bonding at automatic points shall comply with the following:

- Standard Drawing, Bonding Standard Connection Details Drawing Number STD_T3000
- Standard Drawing, Bonding Standard Asset Bonding Layouts Drawing Number STD_T3001
- Standard Drawing, Bonding Standard Long Bonding Layouts Drawing Number STD_T3002
- AS/NZS 3000 Wiring Rules.
- Infrastructure – Overhead Network – Design and Construction, CE-021-ST-0036.

4.1.15 Earthing

4.1.15.1 Earthing of all Yarra Trams assets including the Tram Signalling Controllers shall comply with Standard Drawing Voltage Clamp Design Earthing and Bonding Details STD_T6110 Standard Drawing, Bonding Standard Connection Details Drawing Number STD_T3000 and AS/NZS 3000 Wiring Rules.

4.1.16 Lightning Arrester or Surge Diverter (Arrester)

4.1.16.1 DEHN is the type of Lightning or Surge Diverter that shall be used at all new automatic points locations.

4.1.16.2 The installation of lightning or surge diverters shall comply with the following:

- Standard Drawing, Bonding Standard Asset Bonding Layouts Drawing Number STD_T3001
- Standard Drawing, Bonding Standard Long Bonding Layouts Drawing Number STD_T3002
- Infrastructure – Overhead Network – Design and Construction, CE-021-ST-0036.

4.1.16.3 All bonding of lightning or surge diverters shall comply with Yarra Trams Standard, Infrastructure – Overhead Network – Design and Construction, CE-021-ST-0036.

4.1.17 The Roadbox System

Information: The roadbox system controls motors, gearboxes that open or close the automatic points. There are two types:

- Side mounted motors are being phased out over time and are not included in new designs.
- Centre mounted motors are the preferred type for new automatic points designs.

4.1.17.1 The centre mounted road box by Prazska (Points and motors) shall be the preferred mounting for automatic point movements.

Information: Prazska is an OEM supplying Points and Motors, these are aligned with the Elektroline Vetra detection and signalling system.

4.2 Standard Automatic Points installation

4.2.1.1 Installation of the Elektroline – Vetra Auto Point System including the Prazska Points and Motors shall be in accordance with the manufacturers' installation practices guidelines. Point Signalling Vetra Box and Cable Installation is attached in Addendum 9.4.

4.2.1.2 The installation shall comply with the following Standard Drawings; STD_T3000, STD_T3001, STD_3002, STD_T3005, STD_6110, and STD_T9061.

4.2.1.3 At Standard Automatic Points installations, there must be a primary and a secondary automatic points signal lantern cluster installed (as per specifications below). Please also refer to Yarra Trams Standard drawing for Auto points. (Drawing No: STD_T9057)

4.2.1.4 The primary automatic points lantern shall be installed within a 10 meter distance past the compulsory stopping point at facing points.

4.2.1.5 The secondary automatic points lantern shall be located at a minimum 6m of parallel distance from provisional stopping marks unless a site restriction applies.

4.2.1.6 In a case where the automatic points are used as trailing points and the points must be switched for both directions of movement (non-trailable motors) a primary lantern shall be installed for both travel directions (facing and trailing)

Information: Given the variance in location of signals it must be ensured that the distance chosen takes into account reasonable viewing angles and the blind spots of trams.

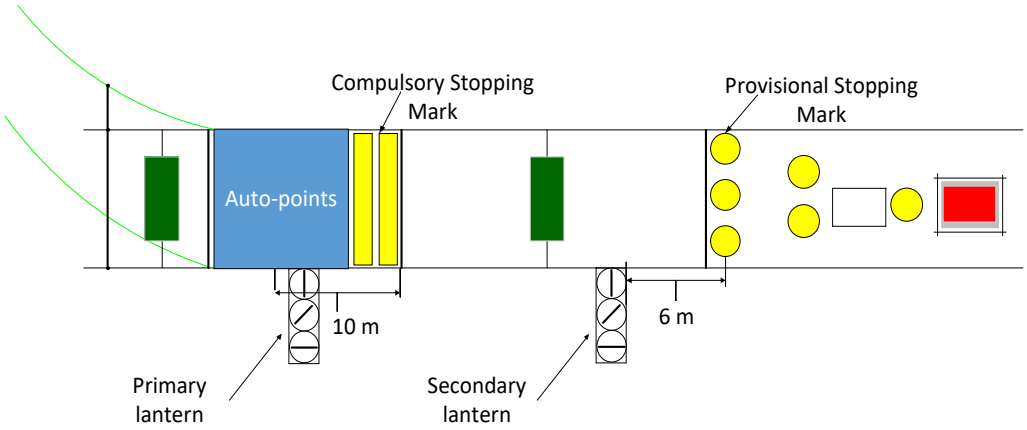


Figure 6 - Example of Tram Signal Lantern Installation

4.3 Aspect Lanterns

4.3.1 Aspect Lanterns

4.3.1.1 Aspect Lanterns also called Tram Signal Lanterns shall be defined as those used as:

- Automatic points signal lanterns
- Signal Systems Lanterns.
- Signal operated points lanterns
- Numbered shunt/road/route allocation signal lanterns.

4.3.1.2 All lanterns that are controlled by Yarra Trams shall comply with the Yarra Trams' "Tram Signal Lantern Standard" SIG – 001-1.0-2017.

4.3.1.3 Those signal lanterns controlled by VicRoads for the movement of trams shall comply with VicRoads Specification TCS 038-2015 "The Supply of Traffic Signal Lanterns".

4.3.1.4 All traffic signal lanterns shall comply with the requirements of the following

- AS 2144:2014 Traffic Signal Lanterns.
- AS 2339 Traffic Signal posts and Attachments
- AS/NZS 3000 Wiring Rules
- AS 60038 Standard voltages

4.3.2 Tram Signal Size and Shape Standards

4.3.2.1 The tram signal lanterns shall have a diameter of 200mm

4.3.2.2 The tram signal lanterns sun visors shall be 200mm in length

4.3.2.3 The tram signal lanterns shall have mounting straps complying with AS 2339:2017 Traffic Signal Post, Mast Arms and Attachments.

4.3.2.4 The tram signal lanterns shall have a minimum of two parallel signals for redundancy.

4.3.2.5 The tram signal lanterns shall be constructed using Light Emitting Diodes (LED).

4.3.2.6 The tram signal lanterns LEDs shall have an operating temperature range from -15°C to +60°C.

4.3.2.7 The tram signal lanterns shall be capable of having masks attached.

4.3.2.8 The tram signal lanterns shall be capable of being dimmed.

4.3.2.9 The tram signal lanterns shall be suitable for use with directional masks.

4.3.2.10 The tram signal lanterns shall not be used with louvers.

4.3.2.11 The tram signal lanterns shall operate on 24Vdc voltage supply.

4.3.2.12 The tram signal lanterns shall have a maximum power usage of 24 watts.

4.3.2.13 The tram signal lanterns shall have the capability to be monitored (current monitored) by the controller.

4.3.2.14 The tram signal lanterns shall be capable of stepped dimming.

4.3.2.15 Tram signal lanterns Individual LED's shall be wired such that a failure of any one LED will result in the loss of not more than 6% of the sign displays total LED's and failure will not give a misleading or opposite display.

4.3.2.16 The tram signal lanterns shall, if less than 80% of the total numbers of LED's in a display are illuminated, the LED display shall automatically shut down by the current monitoring system of the signal controller system.

4.3.2.17 The tram signal lanterns LEDs shall be 5mm in nominal diameter for both white or blue LEDs.

4.3.2.18 The tram signal lanterns LEDs shall be mounted in parallel sectors so that failure of one led group still provides the appropriate signal (although reduced in intensity).

4.3.2.19 In tram signal lanterns the failure of any signal LED group must not create a signal meaning opposite to the original signal intent.

4.3.2.20 The tram signal lanterns shall incorporate a lamp failure indication signal system. The LED shall have a defined resistance to ensure that failure of the signal activates lamp failure detection.

4.3.2.21 The tram signal lanterns LEDs and all other components of the system shall be designed for a minimum life of 10 years.

4.3.2.22 The tram signal lanterns target board shall not be made of Plastic they shall comply with VicRoads Specification TCS 038-2015 "The Supply of Traffic Signal Lanterns" VicRoads Traffic Engineering manual Vol 1, 2 & 3.

4.3.2.23 The tram signal lanterns shall comply with VicRoads Specification TCS 038-2015 "The Supply of Traffic Signal Lanterns" inclusive of VicRoads' Traffic Engineer Manual Vols 1,2 & 3

4.3.2.24 The tram signal lanterns enclosure shall be IP65 (Ingress Protection) rated per IEC standard 60529 Degrees of Protection provided by enclosures (IP Code).

4.3.3 Automatic Points Operation Lantern Aspects

4.3.3.1 A typical automatic switch point shall have matching primary and secondary automatic points signal lantern clusters as following:

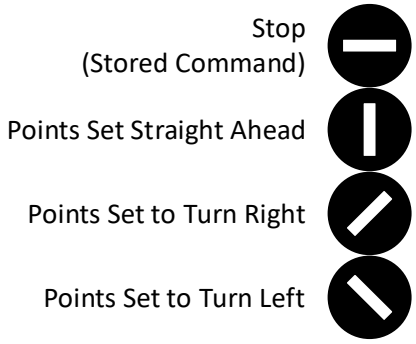


Figure 7 - Automatic Points Lanten Aspects

Information: When a Stop appears by itself with all other lanterns blank the stop becomes a "Do Not Proceed" (possible Point failure).

4.3.4 Signalling System Signalling Lanterns

4.3.4.1 Signal system signal lanterns shall allow accessing the road/route ahead.

4.3.4.2 The top signal lantern shall indicate a mandatory stop (2 x horizontal white lines) or to proceed (Blank).

4.3.4.3 The lower two signal lanterns shall identify the position/orientation or "lay" of the switch blade.

4.3.4.4 These aspects shall indicate the confirmation of acknowledgement that the drivers command has been received (Blue Rectangle).

4.3.4.5 A single round white light indicates an operational error has occurred and a system reset notification.

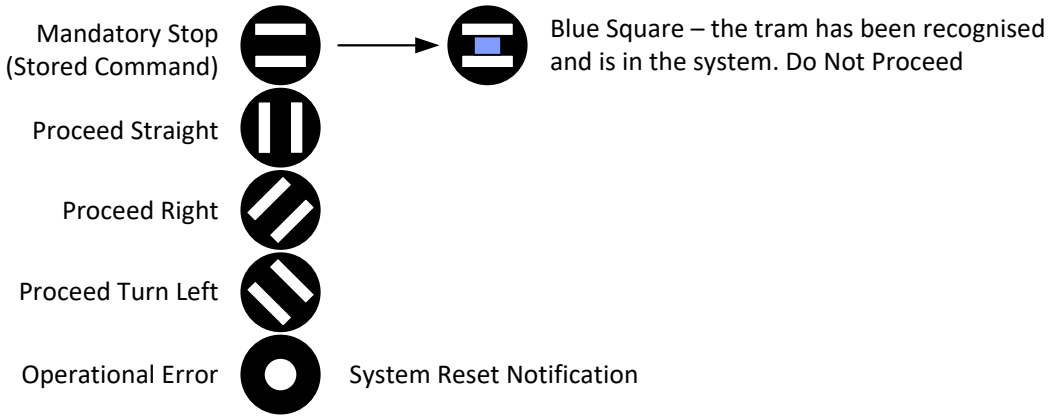


Figure 8 - Signal System Signal Lanterns

4.3.5 Signal Operated Points Signal Lanterns.

4.3.5.1 Signal operated points signal lanterns shall allow tram drivers to pass through facing points with confidence and without needing to physically view the lay of the switch blade.

4.3.5.2 The signal operated points signal lanterns and motors shall be designed to reliably indicate the position/orientation or "lay" of the switch blade.

4.3.5.3 The signal operated points signal lanterns shall indicate the position/orientation or "lay" of the switch blade. These aspects also indicate the acknowledgement that the drivers command has been received (Blue Rectangle) and confirmation that the switch points are safely locked (White Diamond). They can only be changed manually.

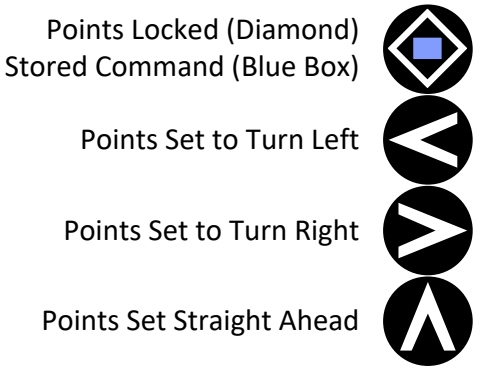


Figure 9 - Signal Operated Points Signal Lanterns

4.3.6 Special Signal Lanterns

Information: Numbered shunt/road/route allocation signal lanterns form the suite of Special Lanterns,

4.3.6.1 Special Lanterns shall include lanterns for depot entrances, road allocations and shall where required interface into the depot Yard Management System (YMS). They shall incorporate the following:

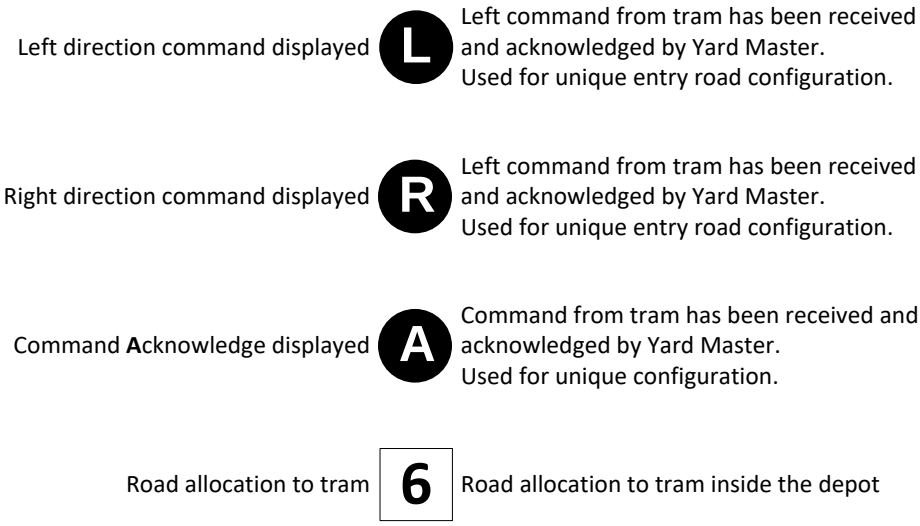


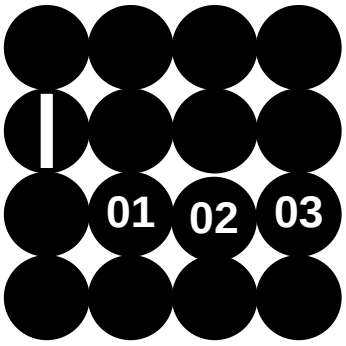
Figure 10 - Special Lanterns used at Depots

4.3.6.2 Special Lanterns shall be included for use at interchange locations. They shall incorporate the following at unique locations such as an Interchange where there may be three-way points facing in the same turn direction.

These Special Lanters indicate the route allocated to the tram direction and the street or road it's to travel via.

Figure 11 - Special Lanterns used at Interchange Locations

4.3.6.3 Special Lanterns shall be included for use at termini locations. They shall incorporate the following at unique locations where multiple routes terminate at the same location with different shunt tracks are available.



Available Shunt number or Point Direction.;

Free and Allocated shunt number or Point direction for Trams where there are three or more shunt tracks.

Figure 12 - Special Lanterns for Multiple Routes Terminus

A flashing orange indicator for operators to proceed with caution.

Figure 13 - Flashing Special Lanterns – Proceed with Caution

4.4 Tram Signal Installation and Locations

4.4.1 General requirements

4.4.1.1 Tram Signal Lanterns shall be installed in a manner that is consistent with locations across the network, given the constraints of operating in a Shared Roadway environment.

4.4.1.2 Tram Signal Lanterns shall be located on the left hand side of the direction of tram travel in a viewing position that aligns with other road infrastructure and avoids the blind spots of trams.

4.4.1.3 Tram Signal Lanterns shall not be installed in proximity (on the same poles) as Vic Roads signal clusters.

4.4.1.4 Tram Signal Lanterns shall be installed on the galvanized steel pole embedded in the reinforced cement and concrete foundation or on a tram pole if suitably positioned.

4.4.1.5 Tram Signal Lanterns should be located at a height no less than 1.8 meters from the surface level.

4.4.1.6 Tram Signal Lanterns shall be installed to ensure that the signals do not present a hazard to pedestrian movements

4.4.1.7 Tram Signal Lanterns shall be installed in the clear line of sight of the tram driver.

4.4.1.8 Tram Signal Lanterns shall not be installed in the blind spot of any type of the tram classes (e.g. Tram Class W, Z, A, B, C, D and E)

4.4.1.9 Tram Signal Lanterns shall be installed on the pole with a maximum viewing angle of 50 degree with respect to Tram axis in the direction of tram movements.

4.5 Track, Stud and Location Marks

Information: Track, Stud and Location Marks are used by drivers for a variety of purposes such as provisional and compulsory stops and shunting marks which require different types to distinguish the location stops for different classes of trams.

4.5.1 General requirements

4.5.1.1 Descriptions of Track and Stud Marks shall comply with Tram Infrastructure Standard Drawing Location of Markers Typical Arrangement and Type STD_T0009.

4.5.1.2 Meanings of Track and Stud Marks shall comply with Yarra Trams "The General Rules and Driving Rules" document.

4.5.1.3 All yellow location marks shall comply with AS2700 Colour Standards for General Purposes being Sunflower Yellow Y15.

4.5.2 Compulsory Stop Mark

4.5.2.1 Compulsory Stop Marks shall consist of two full width yellow bars and shall be used to indicate to trams to stop completely before proceeding and at termini, not proceed beyond the mark.

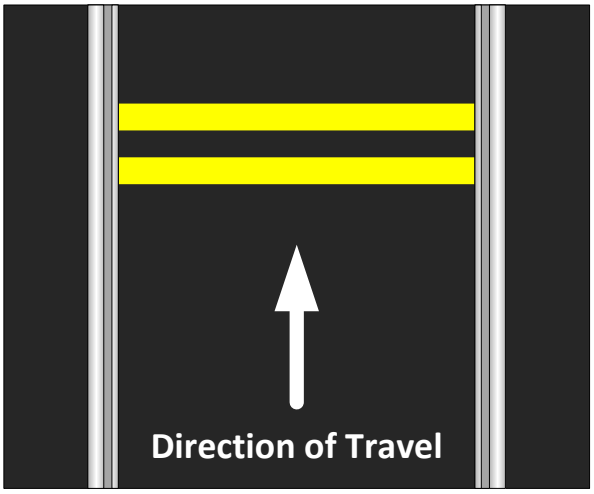


Figure 14 - Compulsory Stop Mark

4.5.2.2 The lines shall be 100mm in depth with a separation of 60mm or up to 100mm depending on the tarmac surface.

4.5.2.3 The lines shall be to the edge of the rails.

4.5.3 Check Point Mark

4.5.3.1 Check point marks shall have the same meaning as Compulsory Stop Mark however they shall not be used in depots.

4.5.3.2 The line length on each side of the indication arm shall be 720 mm long and 100 mm wide.

4.5.3.3 They shall have a separation of 60mm or up to 100mm depending on the tarmac surface.

4.5.3.4 They shall have an internal angle between arms of 140°.

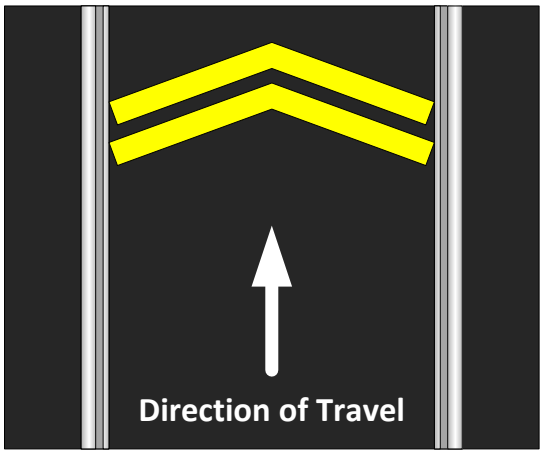


Figure 15 - Check Point Mark

4.5.4 Double Dashed Yellow Line

4.5.4.1 When facing two dashed yellow lines the tram shall be allowed to proceed without stopping at the facing points.

4.5.4.2 A speed limit of 15km/h shall apply.

4.5.4.3 The signals and the points shall be set for the correct direction and not split.

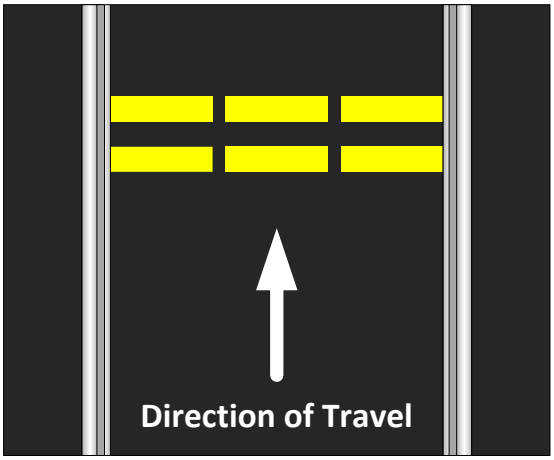


Figure 16 - Double Dashed Yellow Line

4.5.4.4 The lines shall be 100mm in depth with a separation of 60mm or up to 100mm depending on the tarmac surface.

4.5.4.5 The distance between the dashes shall be 60mm.

4.5.4.6 The lines shall be to the edge of the rails.

4.5.5 Fouling marks

Information: Fouling Marks have been included in this standard for the sake of completeness.

4.5.5.1 A one full width yellow bar shall be used to indicate that a tram shall not proceed further due to the danger of fouling a shunting tram.

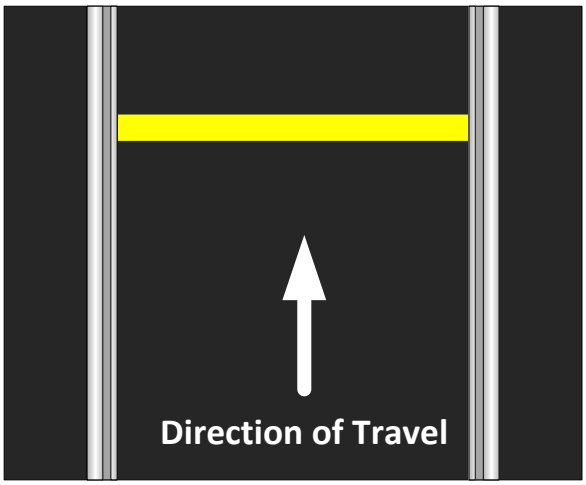


Figure 17 - Fouling Mark

4.5.5.2 The line shall be 100mm in depth.

4.5.5.3 The line shall be to the edge of the rails.

4.5.6 Provisional Stop

4.5.6.1 A provisional stop shall consist of three white round stud marks each 150mm in diameter in a line, with a gap of 150mm, placed in a line 90° to the track centrally between the tracks not less than 300mm from the left-hand rail head.

4.5.6.2 A provisional stop shall be used as a stop position if there is a tram in front that is travelling in an alternative direction through the points.

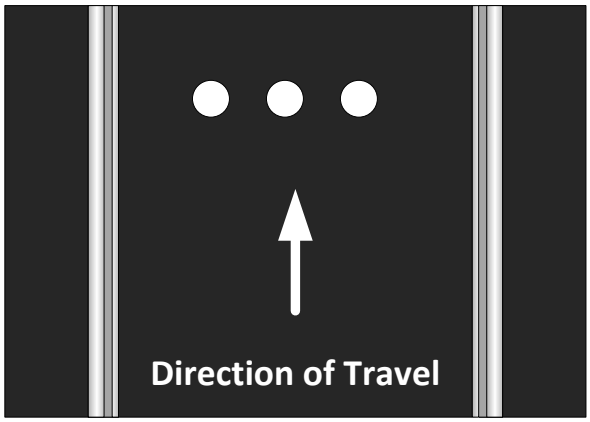


Figure 18 - Provisional Stop Mark

4.5.7 Stopping Place Studs

4.5.7.1 Stopping place studs shall consist of three white square stud marks each 100mm X 100mm in line, with gaps of 50mm between them, placed in a line 90° to the track but not less than 100mm from the inside edge the left-hand rail head.

4.5.7.2 Stopping place studs shall indicate where a tram should stop at a tram stop or platform stop to ensure passenger safety alighting or boarding the tram.

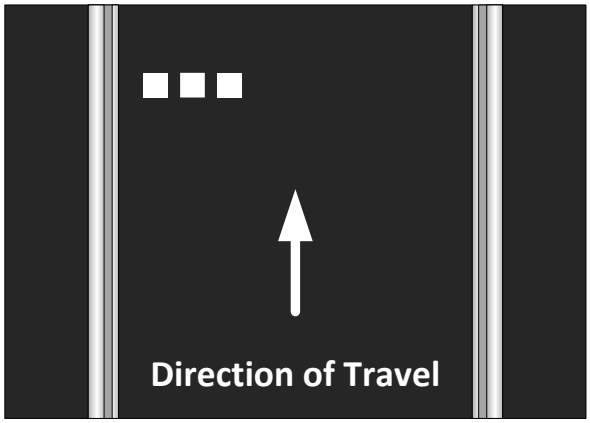


Figure 19 - Stopping Place Studs

4.5.8 Stopping Place Studs for Long Trams

4.5.8.1 Stopping place studs for long trams shall consist of three white diamond shaped stud marks each 100mm X 100mm placed in a line 90° to the track, with gaps of 25mm between them, placed not less than 75mmm from the inside edge the left-hand rail head.

4.5.8.2 Stopping place studs for long trams shall indicate where an E Class tram should stop at a tram stop or platform stop to ensure passenger safety alighting or boarding the tram.

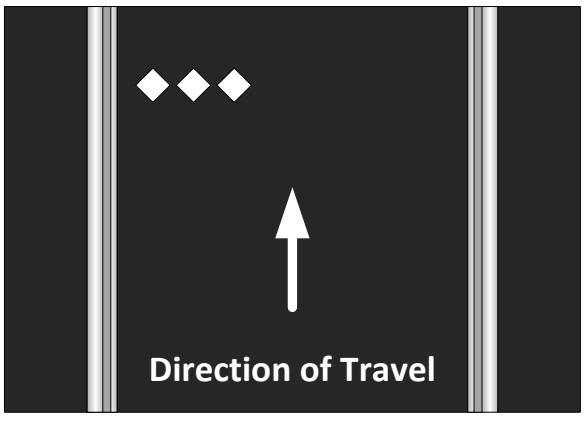


Figure 20 - Stopping Place Studs for Long Trams

4.5.9 Shunting Marks

4.5.9.1 Shunting Marks shall indicate the point where, a class of tram shall be clear of the points and can be driven backwards.

Information: The following figures show the shunting marks for classes of tram.

4.5.10 Shunting Marks for C2, D2 and E Class Trams

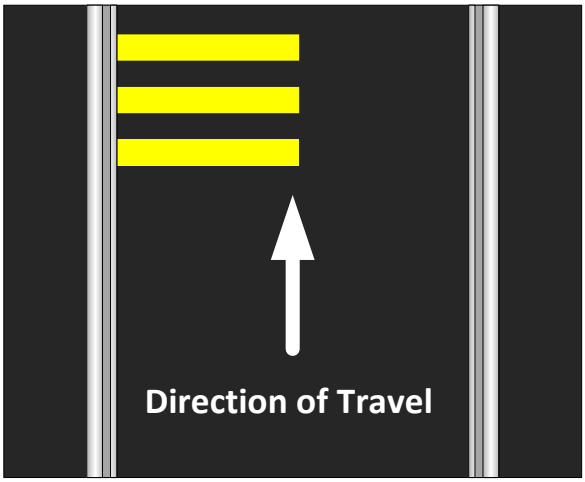


Figure 21 - Shunting Marks for C2, D2 and E Class Trams

4.5.10.1 The lines shall be 100mm wide and 700mm long with a separation of 60mm or up to 100mm depending on the tarmac surface.

4.5.11 Shunting Marks for B, C1, and D1 Class Trams

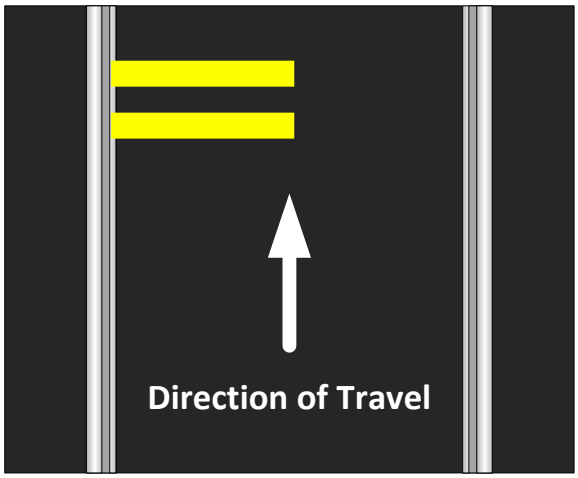


Figure 22 - Shunting Marks for B, C1 and D1 Class Trams

4.5.11.1 The lines shall be 100mm wide and 700mm long with a separation of 60mm or up to 100mm depending on the tarmac surface.

4.5.11.2 The lines shall align to the inside edge of the left-hand rail.

4.5.12 Shunting Marks for A, Z, and W Class Trams

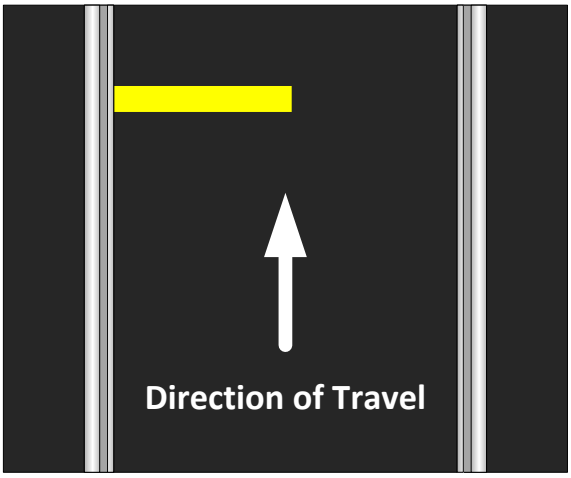


Figure 23 - Shunting Marks for A, Z and W Class trams

4.5.12.1 The line shall be 100mm wide and 700mm long

4.5.12.2 The line shall align to the inside edge of the left-hand rail.

4.5.13 50 / 50 Marks

4.5.13.1 50 / 50 Marks shall be installed at nominated safe locations for trams to stop to avoid detection and interference with trams at multi route corridors interchange locations.

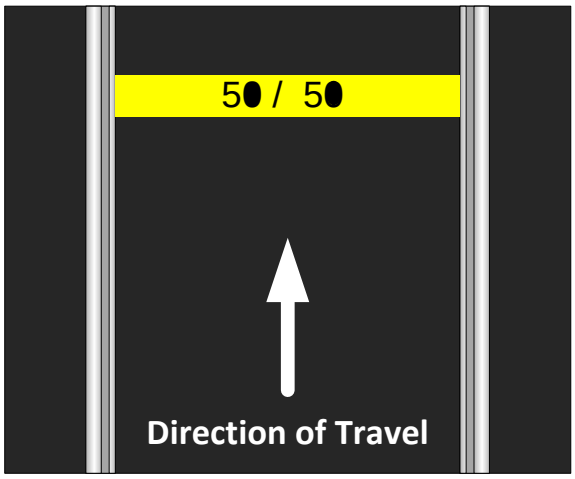


Figure 24 - 50 / 50 Marks

4.5.14 Tram Terminus Marks

Information: Tram Terminus marks indicate the point where; a class of tram is clear of the points and can be driven backwards.

The following figures show the Terminus Marks for the different classes of tram.

4.5.15 Terminus Marks for C2, D2 and E Class Trams

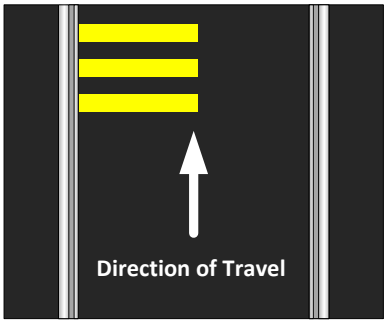


Figure 25 - Terminus Marks for C2, D2 and E Class Trams

4.5.15.1 The lines shall be 100mm wide and 700mm long with a separation of 60mm or up to 100mm depending on the tarmac surface.

4.5.15.2 They shall align to the edge of the left-hand rail.

4.5.16 Terminus Marks for B, C1, and D1 Class Trams

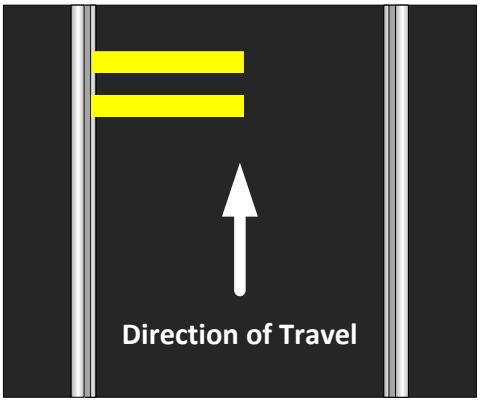


Figure 26 - Terminus Marks for B, C1 and D1 Class Trams

4.5.16.1 The lines shall be 100mm wide and 700mm long with a separation of 60mm or up to 100mm depending on the tarmac surface.

4.5.16.2 The lines shall align to the edge of the left-hand rail.

4.5.17 Terminus Marks for A, Z, and W Class Trams

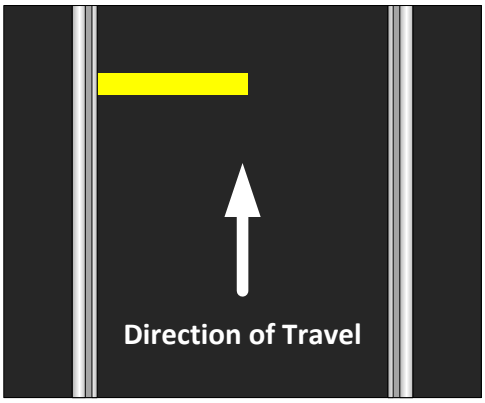


Figure 27 - Terminus Marks for A, Z and W Class trams

4.5.17.1 The line shall be 100mm wide and 700mm long.

4.5.17.2 The line shall be to the edge of the left-hand rail.

4.5.18 Hatch Markings

4.5.18.1 Hatch Marks vary in size depending on the location and the width of the Tramway however they shall cover the path of the tram in both directions.

4.5.18.2 Hatch Markings shall indicate to operators that there is insufficient clearance between trams if a tram is occupying (moving through) the hatched marked area.

4.5.18.3 Operators shall not enter the hatched marked area if there is another tram or part of a tram already in the zone.

4.5.18.4 An operator shall only enter the hatched marked area only if they can proceed through it without stopping.

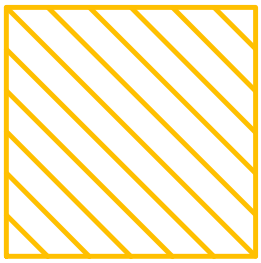


Figure 28 - Clearance Hatch Marking

4.5.19 Section Isolation

4.5.19.1 For all new designs the 2013 Section Isolator Marking System shall be used as follows. Refer to “The General Rules and Driving Rules” and Standard Drawing Location of Markers Typical Arrange and Type Drawing Number STD_T0009.

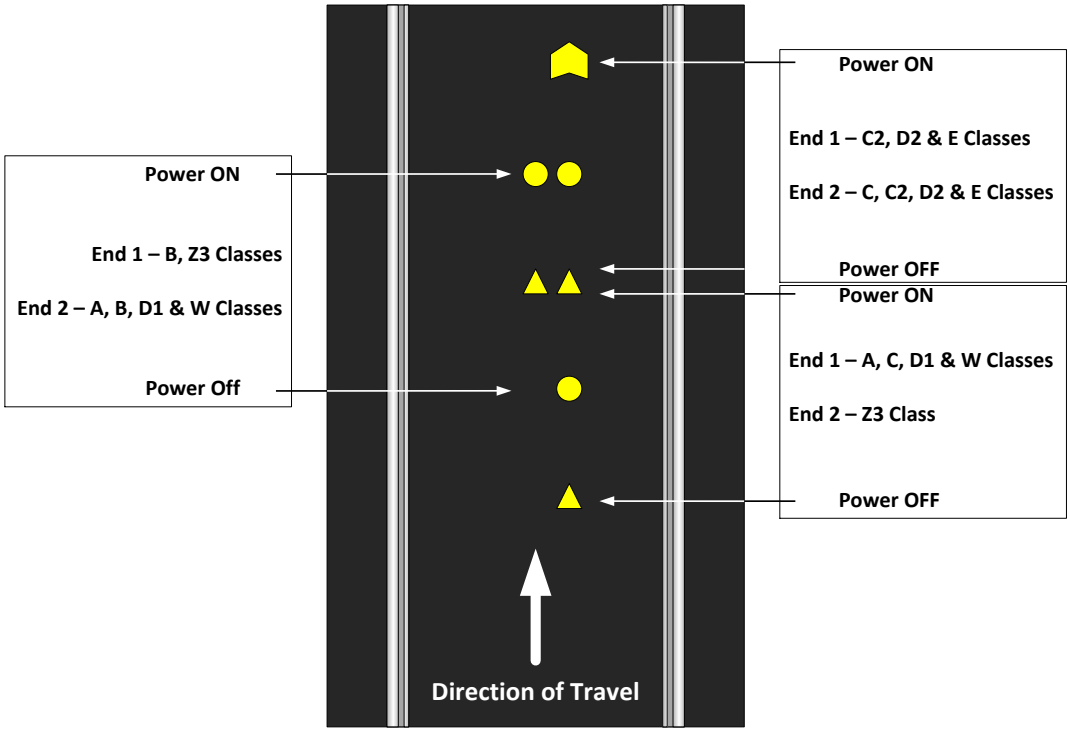


Figure 29 - 2013 Section Isolator Marking System

4.5.19.2 2013 Section Isolator Marks shall conform to the following dimensions per Standard Drawing "Location of Markers Typical Arrange and Type" Drawing Number STD_T0009.

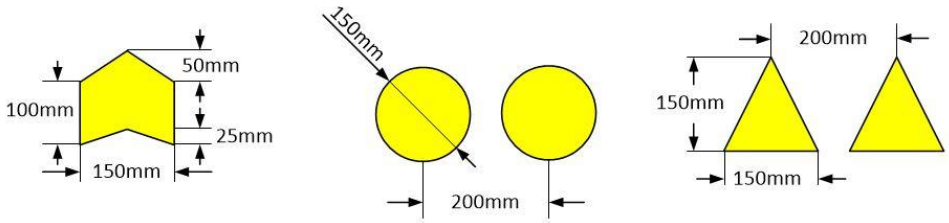


Figure 30 - 2013 Section Isolator Marks Dimensions

4.5.19.3 The 2013 Section Isolator Marks shall be placed in on the tramway using the following measurements per Standard Drawing Location of Markers Typical Arrange and Type Drawing Number STD_T0009.

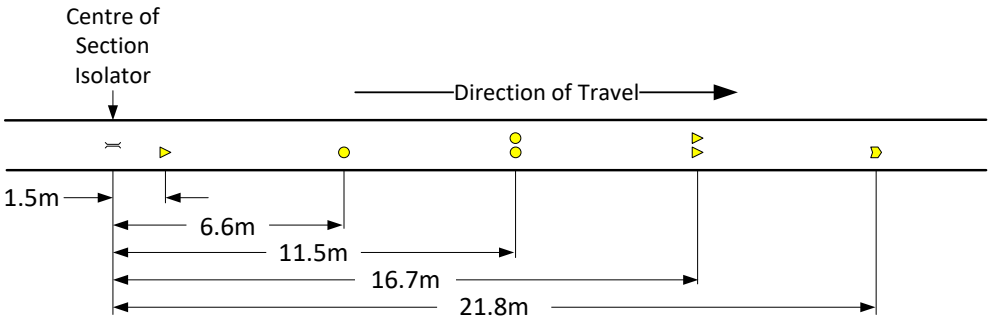


Figure 31 - 2013 Section Isolator Marking System Distances

4.5.20 Point Command Stud Marks at Automatic Points

4.5.20.1 At automatic points a single white round stud mark 150mm in diameter placed centrally between the tracks, not less than 600 mm from the rail left hand head, shall be used as the position to issue a setting command.

4.5.20.2 At automatic points two white round stud marks 150mm in diameter placed centrally between the tracks with a gap of 200mm and not less than 425mm the left-hand rail head, shall be used as the position for the release setting command.

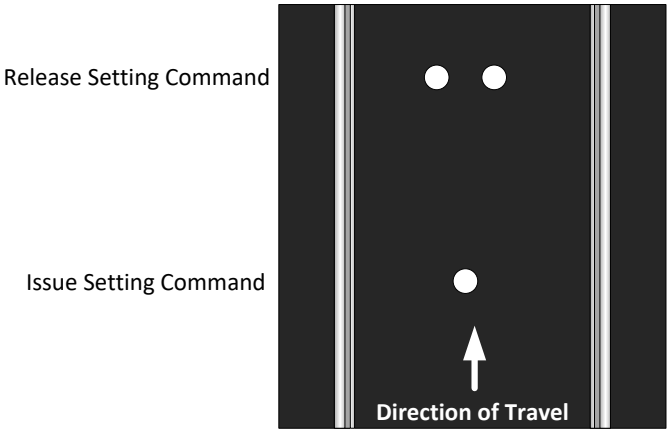


Figure 32 - Point Command Stud Marks at Auto Points

4.5.21 Point Command Stud Marks at Signal Operated Points

4.5.21.1 At signal operated points a single white round stud mark 150mm in diameter inside a blue diamond edged at 200mm, placed centrally between the tracks, not less than 600 mm from the rail left hand head, shall be used as the position to issue a setting command.

4.5.21.2 At signal operated points two white round stud marks 150mm in diameter shall be placed centrally between the tracks with a gap of 200mm and not less than 425mm the left-hand rail head and shall be used as the position for the release setting command.

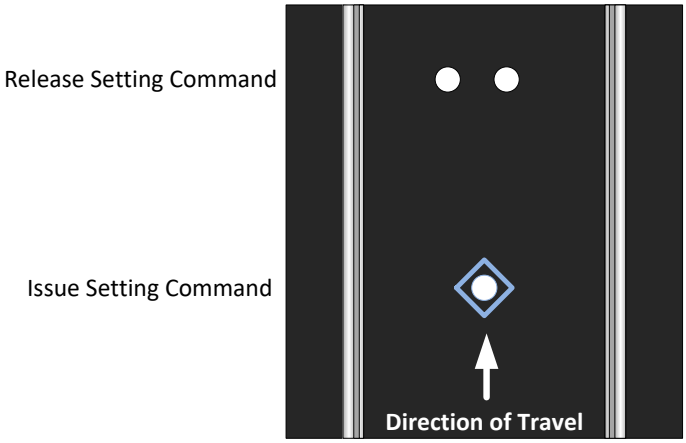


Figure 33 - Signal Operated Points Stud Marks

4.6 Stud and Location Mark Dimensions

4.6.1 New designs

4.6.1.1 For all new designs the for Stud and Location Marks the distances and dimensions shall be as per Standard Drawing Location of Markers Typical Arrange and Type Drawing Number STD_T0009.

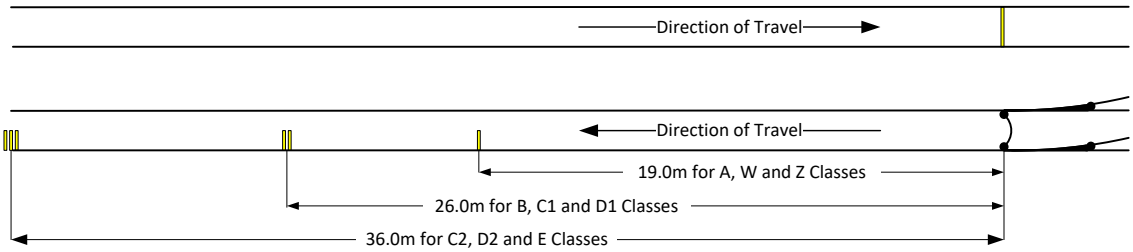


Figure 34 - Location Mark Track Distances

5 DIAGRAMS AND GUIDANCE

5.1 Referenced Drawings

Title	Drawing No
Standard Drawing, Bonding Standard Connection Details	STD_T3000
Standard Drawing, Bonding Standard Asset Bonding Layouts	STD_T3001
Standard Drawing, Bonding Standard Long Bonding Layouts	STD_T3002
Standard Drawing, 600V Supply Pole to Autopoints Cabinet Layout	STD_T3003
Standard Drawing, Automatic Points Equipment Cubicle and Concrete Base	STD_3005
Standard Drawing Location of Markers Typical Arrange and Type	STD_T0009
Standard Drawing Voltage Clamp Design Earthing and Bonding Details	STD_T6110

6 RELATED LEGISLATION & DOCUMENTS

Name	Document Number
Australian Standard Colour Standards for General Purposes	AS 2700:2011
Australian Standard Traffic Signal Lanterns	AS 2144:2014
Australian Standard Traffic Signal Posts, Mast Arms and Attachments	AS 2339:2017
Australian Standard Wiring Rules	AS/NZS 3000
Electricity Safety (Installations) Regulations 2009	
General Rules and Driving Rules (2017)	
IEC Standard: Supply Voltages for Traction Systems	IEC 60850 (2014)
IEC Standard: Degrees of Protection provided by enclosures (IP Code)	IEC 60529 (2001)
IEC Standard: Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems	IEC 61508
IEC Standard: Requirements for bodies certifying products, processes and services — Conformity assessment	ISO/IEC 17065 (2012)
IEC Standard: Standard Voltages	IEC 60038 (2009)
Infrastructure – Overhead Network – Design and Construction	CE-021-ST-0036
Occupational Health & Safety Act 2004	
Occupational Health & Safety Regulations 2007	
PTV Infrastructure Drafting Standards Version 1.0	
Rail Safety National Law	
Tram Infrastructure Standard Drawing Autopoints Typical Set Out	STD_T9057
Tram Infrastructure Standard Drawing Autopoints Construction Details	STD_T9061
Tram Track Standard Drawing Tramway Structure Gauge	STD_T9000
VicRoads Specification: The Supply of Traffic Signal Lanterns	TCS 038-2015
VicRoads Traffic Engineering Manual	Vols 1, 2 and 3
Yarra Trams Bonding Application Guide	BAG_21_06_2017
Yarra Trams Electrical Infrastructure Safety Rules	IN-002-ST-0002
Yarra Trams Line Marking and Signage Standard	20150529
Yarra Trams Specification and Application of tram signals	SIG - 001 – 1.0 – 2015
Yarra Trams Tram Signal Controller Standard	SIG – 002 – 1.0 – 2017
Yarra Trams Tram Signal Lantern Standard	SIG – 001 – 1.0 – 2017

7 DOCUMENT VERSION CONTROL

Version History	Date	Detail
1.0	20 Mar 2020	Original approved issue

8 APPENDIX A – GLOSSARY

Word	Definition
Conflicts	The consequent upsurge in road traffic paralleling the tram route meant increasing conflicts arising at points where trams encounter vehicles. Closely controlled traffic signals became essential at all these points to give priority to the passage of trams.
Transponder	The transponder is a wireless communication device that constantly emits a radio frequency signal; its information can only be sensed locally via induction detection loops.

9 ADDENDUM

9.1 Track Location Marks STD_T0009 1/3

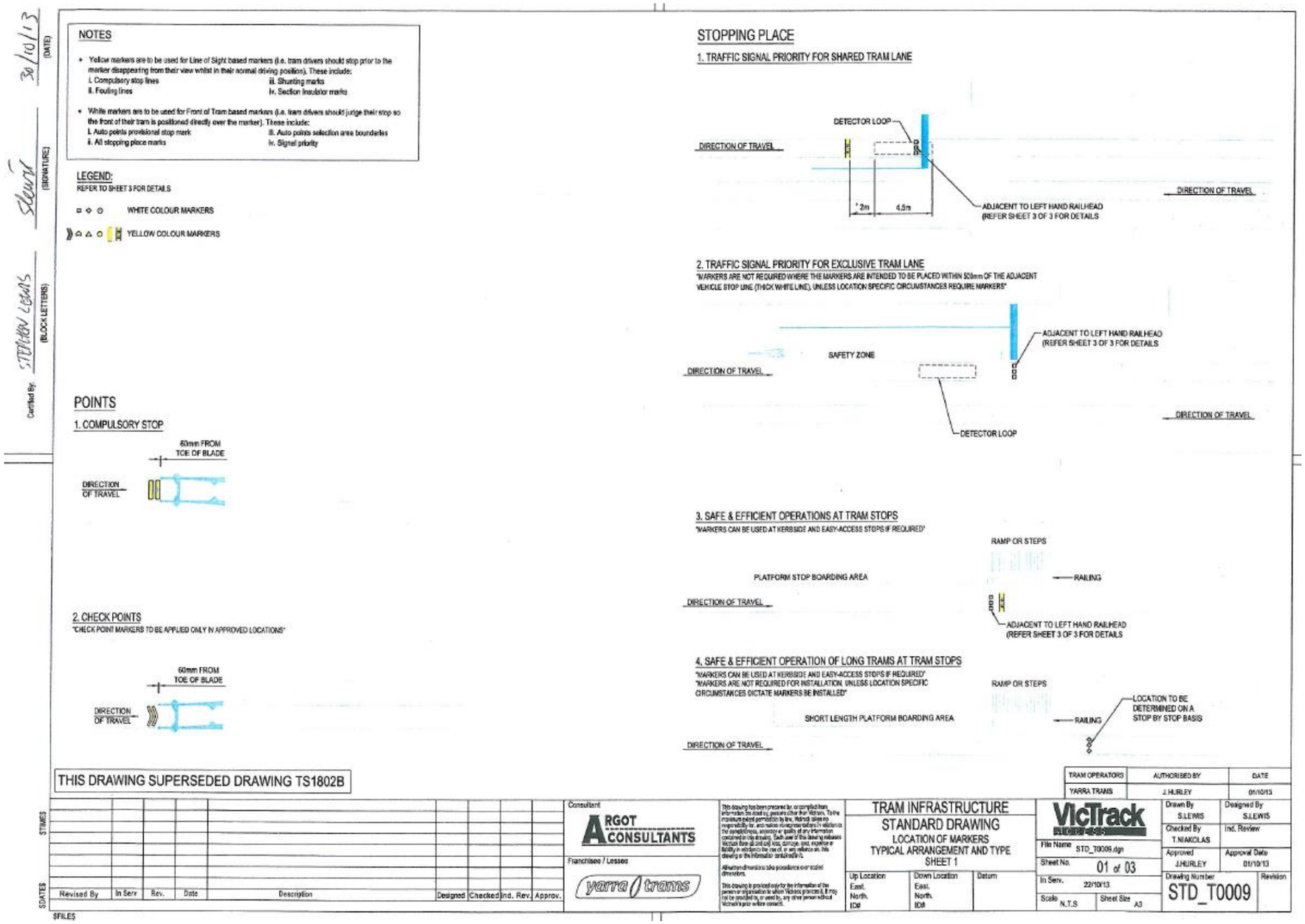


Figure 35 - Standard Drawing Location of Markers Typical Arrange and Type STD _T0009 1 of 3

9.2 Track Location Marks STD_T0009 2/3

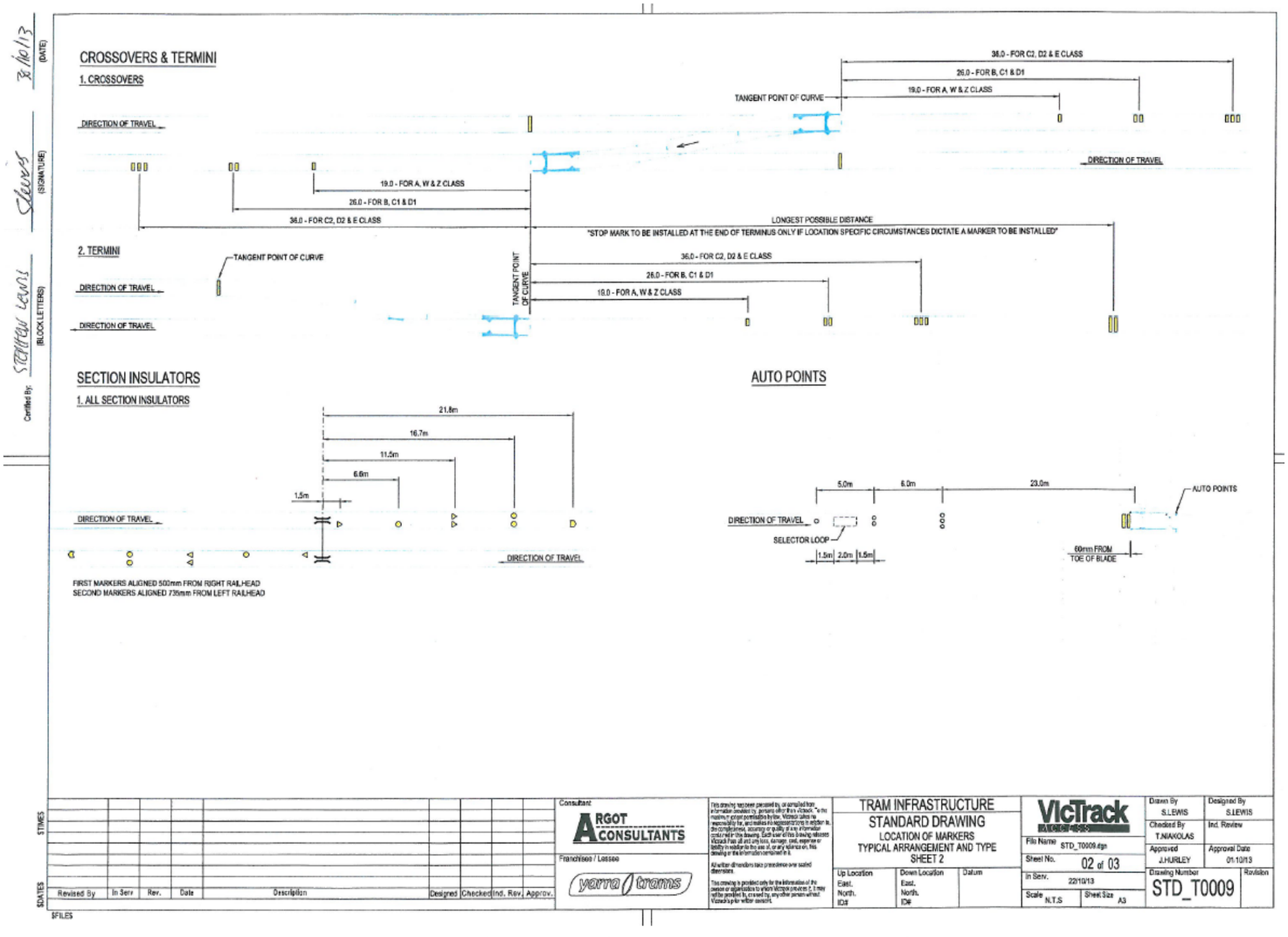


Figure 36 - Standard Drawing Location of Markers Typical Arrange and Type STD _T0009 2 of 3

9.3 Track Location Marks STD_T0009 3/3

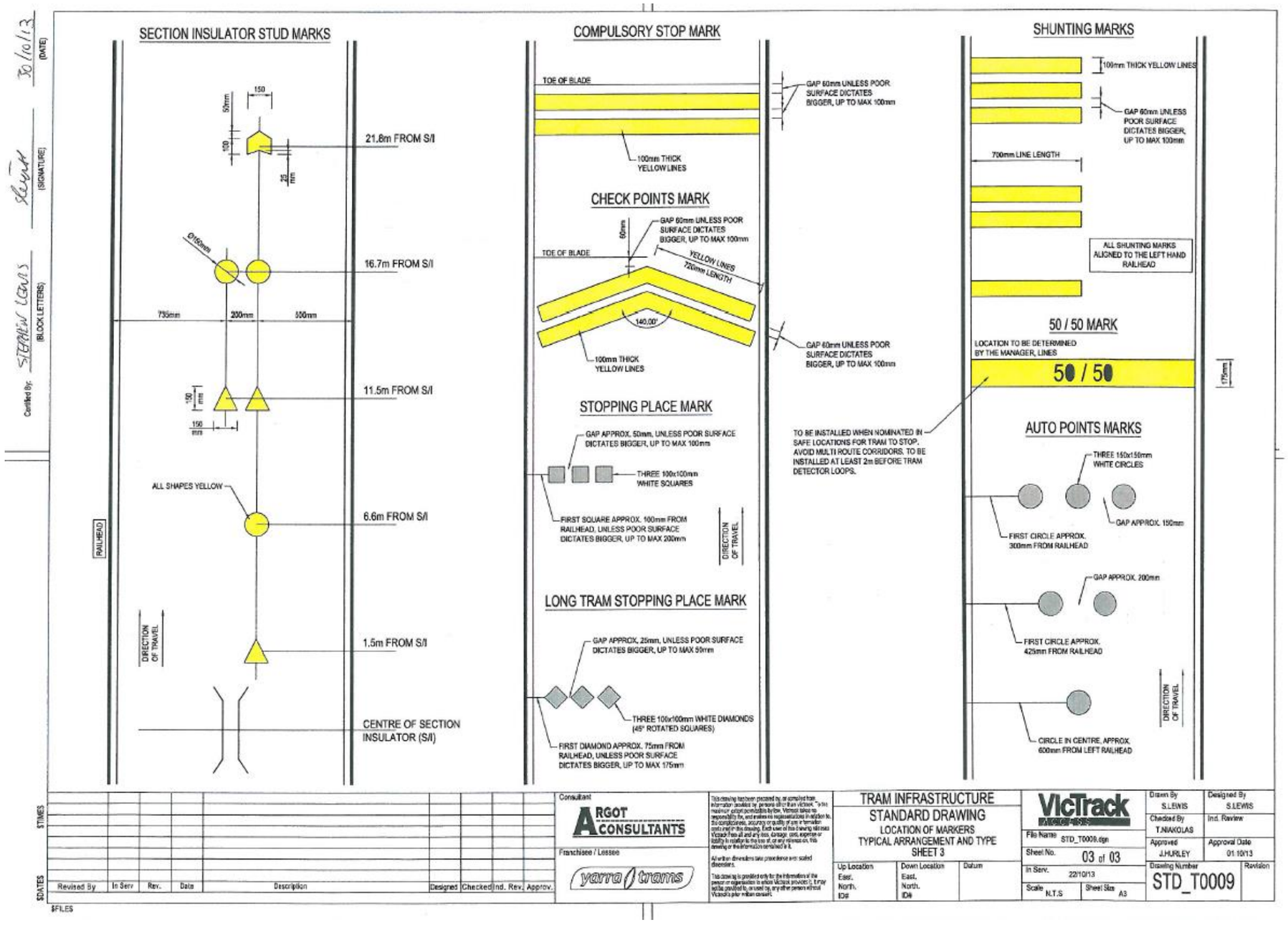


Figure 37 - Standard Drawing Location of Markers Typical Arrange and Type STD _T0009 3 of 3

9.4 VETRA Box Installation

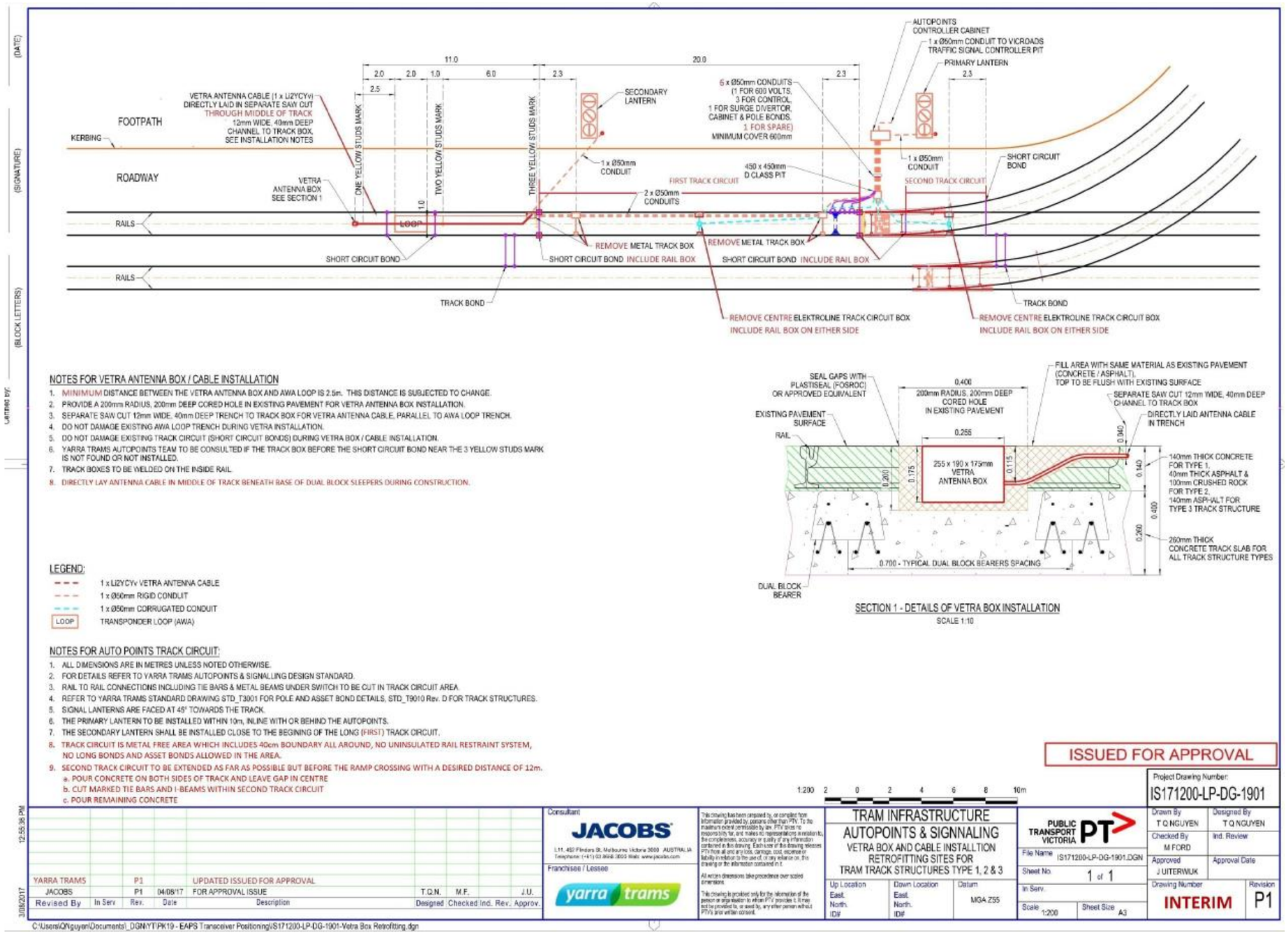


Figure 38 - Auto Point Signalling Vetra Box and Cable Installation