Appendix B – Device use requirements

MANADATORY APPENDIX

B.1 Scope

This Appendix provides requirements, recommendations and information on the use, installation, operation and removal of some of the devices in *Section 6 Signs and devices*.

B.2 Usage procedure: Type 2 (automatic) portable traffic signal systems

B.2.1 Introduction

This Section supplements the requirements of *Section 6.6.3 Type 2 (automatic) portable traffic signal (PTS) systems* and provides basic information to effectively use portable traffic signals (PTS) to control traffic that have 'automatic' functionality. It applies equally to both Transport and other bodies working on roads, such as councils, contractors and public utility authorities. It gives a description of the operational features of the equipment including details for the selection of appropriate signal timings and model situation diagrams showing the required signposting and site layout for the signals.

Type 2 PTS may be used for traffic control applications lasting up to three months. For sites where work will continue for longer periods, without the location of the work site changing, a risk assessment and feasibility analysis must be carried out to determine whether the extended use of portable signals is acceptable or whether a temporary signal installation should be provided. This risk assessment and feasibility analysis must be submitted to Traffic Engineering Services for review and the concurrence of the Director Traffic Engineering Services obtained for the use of portable signals for longer than three months.

B.2.2 Specification and type approval

PTS systems with automatic functionality must be compliant to Transport Specification TSI-SP-049, Portable Traffic Signal Systems.

Testing of equipment is to be undertaken by the Transport's Intelligent Transport Systems Branch. After type approval has been issued, the manufacturer or selling agent must affix, to the equipment, a durable marking plate in the following format (*Figure B-1*):

Figure B-1. Marking plate

The number shown on the marking plate must match the number on the type approval certificate issued by the Transport's Intelligent Transport Systems Branch.

Arrangement for copies of the TSI-SP-049 and type approval testing should be directed to:

- “Transport Traffic Equipment and Standards” at ITSHelpdesk@rms.nsw.gov.au;
- A list of current type approved equipment can be found in Transport specification TS200 (Register of ITS Field Equipment).

Type approved equipment is to be operated in accordance with this Section and the manufacturer's instructions. A record must be kept of the approval and the period of operation of the traffic signals and may be required in court, in case of an accident or traffic infringement, see *Table B-1*.

Table B-1. Portable traffic signals, record of approval and use

Portable Traffic Signals Record of Approval and Use				
Approval: (To be completed by a person with delegated authority) Approval is given to the use of portable traffic signals which have been separately type approved to Transport specification, TSI-SP-049 as detailed hereunder.				
Owner:		Signed:		
User:		Title:		
Project:		Date:		
Use: (To be completed by the Users representative)				
Job location:				
Portable signals in service				
Date	Time (24 hour)	Supervisors name, please print	Initials	Mode* of operation
This completed schedule should be kept by the relevant approving authority for a period of two years as a record of the display. *__Note__ MAN/1 – Manual Shuttle Operation, MAN/2 – Manual Two-way Operation, VA – Vehicle Activated Shuttle Operation, FT – Fixed Time Shuttle Operation				

Temporary traffic signal installations using fixed equipment and cables are not covered by this Section and will need to be authorised and inspected in the same manner as permanent installations.

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B.2.3 General description of system

Each set of PTS equipment with automatic functionality will normally comprise:

- Two signal stands, incorporating signal lanterns, vehicle detectors and control equipment;
- Power pack of batteries or generator;
- Operational spares i.e. chassis and plug panel sub–assembly, controller module, lamp switch module, radio module, signal lantern assembly, lamps and fuses, target board assembly and microwave detector;
- Detector checking unit; and
- Remote manual control box.

Shuttle flow

For shuttle flow on a two lane two–way road, one set of PTS is required.

The normal mode of operation is vehicle–actuated using microwave detectors mounted above and integrally with the vehicle signal lanterns. It is also possible to use the signal equipment in either manual control mode (shuttle operation) or fixed–time cycle mode, without the use of the detectors. Under shuttle operation, the operator determines the direction of traffic flows at any time. One direction faces a green display while the other faces a red display.

Plant crossing control

For heavy machinery crossing applications, one set of portable signals is required. This set is used to control traffic on the public road with one set of lanterns on each approach. Traffic on the haul road is not usually directly controlled.

Manual operation is safer and more effective in preventing delays to both public road traffic and haul vehicles. Under manual control i.e. two–way operation, the operator determines when the public road traffic needs to stop to allow the haul vehicles to cross. Both directions face the same display, either green or red.

If aspects are required to be displayed to haul traffic then a second set of signals is necessary which are linked to the public road signals. These signals will be arranged to display red when the other set is green and vice versa.

B.2.4 Signposting and traffic arrangements

General

For shuttle flow, the signal stands should normally be located on the shoulder at the start of the taper or at least 30 m clear of the full lane closure. They should be in clear view of approaching drivers. However, if it is found that vehicles in the non–barricaded approach lane are disregarding the signals or are travelling too fast through the work site, then consideration may be given to installing a chicane arrangement in this lane in order to slow approaching traffic as well as allowing conspicuous positioning of the signal lanterns. This should be documented in the site-specific TMP and risk assessment. The dimensions should be selected to suit site conditions, such as the prevailing road geometry, sight distance and vehicle speed. However, it should be noted that the use of the chicane arrangement substantially increases the length of the controlled area and thus imposes the penalty of longer all–red clearance times and increased traffic delays.

Sight distance

Sight distance on the approach to portable or temporary traffic signals must be a minimum of 150 m.

In open road areas or higher speed environments where traffic signals might not be expected, a Traffic Lights symbolic (W3-3) sign with an __ m (W8-5) sign to indicate distance, should be provided to give advance warning. The position of these signs should take into account the expected queue length from traffic signals and the stopping distance required for heavy vehicles. Consideration should also be given to installing a portable VMS on each approach as an additional form of advance warning.

B.2.5 Equipment installation

Signal lanterns

Normally one signal lantern is used on each approach thereby requiring only one set of equipment for effective working on one road. PTS with automatic functionality complying with Transport Specification TSI-SP-049 have a facility to connect a second lantern assembly. This would be useful on a wide carriageway.

The lantern must be placed so as to give approaching drivers a conspicuous signal and also to be clearly visible to drivers stopped behind the stop line. The signal aspects should be aimed towards the vehicular traffic whereby vertical adjustment is by adjusting the lantern on the stand and horizontal adjustment is arranged by positioning the stand itself on the ground. In practice, the aiming of the vehicle detectors located on top of the lanterns is more critical than the lanterns so the main emphasis of the aiming operation should be as detailed in *Vehicle detectors* below.

Generally, the signal unit should be positioned so as to be as nearly as possible in the driver's line of sight. It is essential to locate signals so the driver has sufficient sight distance to stop on a red display. The minimum sight distance to the signal lantern required for stopping depends on the vehicle type and vehicle speed in the approach to the work area. *Table B-2* provides a guide to stopping sight distances on level bituminous or concrete surfaces.

Table B-2. Stopping sight distances for cars and laden trucks on level pavements

Vehicle speed (km/h	Stopping sight distance (m)	
	Cars	Trucks
50	*60*	*80*
60	*80*	*100*
70	*100*	*130*
80	*120*	*160*

Note to Table B-2. *Increase the stopping sight distance by 2% for each 1% of downgrade. Decrease the stopping sight distance by 2% for each 1% of upgrade.*

Signal stands

The signal stands must be securely erected and anchored to prevent excess movement or interference by vandals.

Controller

The controllers allow for two–phase operation only. Each stand has a control module, one of which must be switched to ‘master’ operation, the other to ‘slave’ operation. To provide remote manual operation, a special box is connected by cable to the ‘master’ unit.

The controller is provided with manual controls (switches) for selecting:

- Power: ON/OFF;
- Master/slave selection;
- Mode selection:

- Manual (shuttle operation);
- Manual (two way operation);
- Fixed time/vehicle actuated.

- Manual advance: for manual selection of phases;
- Yellow time: pre–select 4 seconds or 5 seconds;
- All–red time: pre–select in the range 2 seconds to 100 seconds for fixed time and vehicle actuated operation;
- Maximum green time: pre–select in the range 20 seconds to 150 seconds for fixed time and vehicle actuated operation. The minimum green time is fixed at 15 seconds.

The control equipment provides that in the event of internal failure, a loss in radio communications or low battery voltage, the signals revert to flashing yellow.

Communication

The two signal stands, incorporating the signal lanterns and detectors, are linked either by radio or cable control.

Vehicle detectors

Vehicle detectors are used to relay an electrical impulse to the controller when a vehicle approaches. One detector per approach is required.

Microwave detectors may be located on top of the traffic signal lantern and the beam from the transmitter is reflected back to its receiver by the approaching vehicle. The microwave detector will only detect objects moving towards it. Care must be taken to ensure that unwanted vehicles such as construction vehicles, do not actuate the detector.

Response of the microwave detector will depend on the speed of movement and the size of the target object. In general terms, the unit, when positioned to ‘look’ at an approach, should detect:

- A motorbike moving within the 20 m to 5 m range from the unit; and
- Other larger motor vehicles moving within the 30 m to 5 m range from the unit.

This is assuming that the detector is mounted at a height of between 2.5 m and 3 m and the object being detected is moving at a speed of greater than 5 km/h.

It must be emphasised that the detector should be positioned in such a way that its beam axis is pointed at the centre of the target area and at a distance of approximately 25 m to 35 m ahead of the unit.

For single lane approaches it is suggested that the unit be aimed more towards the road edge. This will result in an increased ‘sensitivity’ to the desired vehicular movements, but at the same time decrease the sensitivity to vehicles travelling away on the departure side of the street. Although the departing vehicle will not produce a detection output, it can cause a ‘swamping’ or masking of a signal being reflected by an approaching vehicle.

In practice, aiming of the microwave detector is achieved by moving the complete stand, adjustment in the horizontal plane, and by tilting the lantern by the adjustment at the top of the stand, adjustment in the vertical plane. A visual indicator built into the rear of the detector case assists in the aiming operation. Vehicles should be able to be detected as indicated by the visual monitor at a distance of 5 m to 30 m ahead of the signal stand.

An illustration of how the detectors work is given in *Figure B-2*.

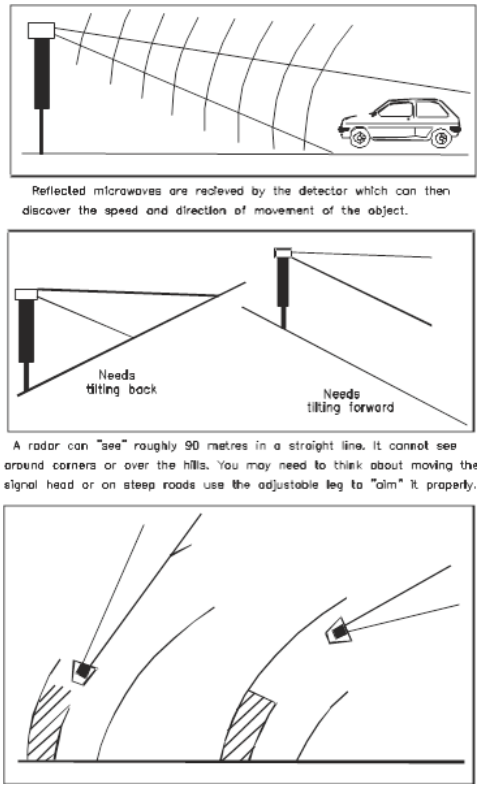

Figure B-2. Illustration of microwave detector operation

B.2.6 Manufacturer's instructions

Operators should familiarise themselves with the manufacturer's Instructions. Field service usually covers:

- Simple fault diagnosis and associated replacement of the faulty modules;
- Routine maintenance including replacement of lamps and other expendable components.

Note: *This Section does not replace the field service manual and operating instructions accompanying each set of equipment. It is most important that operators are fully acquainted with the manufacturer's instructions and recommendations before attempting to operate the equipment.*

B.2.7 Performance

For manual operation, a remote control box would generally be connected by cable to the 'master' unit, although the equipment can be manually operated at the 'master' stand.

Note: *Either unit will operate as a 'master' or 'slave'.*

Use of a cable enables the operator to be located safely away from the road in a position where both approaches to the work area are visible. The 'master' unit should then be selected on the basis that the connecting cable should not cross the roadway. For automatic operation, a full–time operator is not required. The operator fixes the initial settings and then monitors the performance intermittently.

Manual mode (shuttle operation)

With manual mode (shuttle operation), the operator controls the sequence in which green aspects are displayed, and also the 'all–red' and 'green' times. The 'minimum green' time cannot be varied by the operator and is fixed at 15 seconds. The 'yellow' time is pre–selected, as appropriate, to 4 or 5 seconds. The 'all–red' time has a minimum value of 2 seconds but the termination of this period is controlled by the operator. The length of the 'all–red' period should be kept to a minimum consistent with the need to clear the controlled area of opposing traffic.

Manual shuttle operation is applicable when any of the following occur:

- A risk assessment has demonstrated that use of PTCD mitigates the risk associated with use of a manual traffic controller;
- Movement of works traffic prevents the effective use of vehicle actuated or fixed time operation; or
- A detector fails, when using the vehicle actuated mode and it is not desired to use fixed time mode.

Manual mode (two-way operation)

With manual mode (two-way operation), the duration and sequence of displays is determined as in Operation (Control modes). The length of the 'all–red' period should be kept to a minimum, consistent with the need to provide for movement of road machinery without interference from normal traffic.

Manual two-way operation is applicable when:

- All traffic needs to be stopped to allow the passage of traffic on a haul road;
- Traffic must be kept out of the work area for an extended period, such as during blasting, priming or full width bitumen sealing.

Vehicle-actuated operation

This mode of operation allows the signals to operate automatically in response to vehicle demands. The signals will change in response to a demand registered by vehicles as they actuate a vehicle detector and the cycle length is adjusted automatically to suit traffic flows.

Vehicle–actuated operation is applicable when either of the following apply:

- Automatic control is required during working hours which allows the signals to operate unattended while still being responsive to changes in traffic flows; or
- Traffic control is required outside working hours so signals can operate unattended provided the power supply is maintained.

The signals must be inspected by the operator at least once per day to ensure that the detectors are functioning correctly and that there are no burnt out lamps and to arrange the daily change of batteries or other servicing. This is particularly important if the site is unattended on weekends. On weekdays, the signals should be checked immediately prior to start and completion of work.

If a detector malfunction is found, the equipment should be switched to fixed–time operation or if an operator is available, to manual operation.

Following the initial switch on and 'master/slave' selection, the operation is as follows:

Step 1: Initially red is displayed on all approaches for a period of at least 10 seconds then each approach in turn receives a green display for its selected 'maximum green' time with a 'yellow' display and 'all–red' display between each green display.

If the signals are switched from the 'manual' or 'fixed–time' modes of operation to the 'vehicle–actuated' mode, the control equipment will automatically register an artificial demand for each phase for the first cycle.

Step 2: After all phases have been called automatically for the first cycle, the signals will change only in response to vehicle demands.

Step 3: If vehicles approach consistently from only one direction, the controller holds the green display on that approach.

Step 4: When a vehicle is detected on another approach, the signals can change in one of two ways:

- When vehicles approach the first phase as a steady stream, the phase holds for the 'maximum green' time before changing to the new approach.

- When the gap between vehicles approaching the first phase is greater than 5 seconds, the signals will change to the new phase, subject to the limitations of the 15 second ‘minimum green’ time, and after the selected yellow and all–red times.

In the absence of any demand, the signals will revert to ‘all–red’ until a vehicle is detected. This feature ensures that the signals are then able to give right–of–way to the first approaching vehicle with minimum delay.

If the phase changes at the ‘maximum green’ time, a new demand is automatically entered for the terminated phase when the phase changes. This ensures that approaching vehicles stopped by the red display will be cleared at an early time. Otherwise, new demands for the terminated phase will only be registered when the arrival of an additional vehicle actuates the detector of that phase.

As a safety feature, when using microwave detectors, an automatic demand will be introduced for any phase or approach which has not received a detector actuation for approximately 200 seconds.

Fixed-time operation

As this form of control does not allow for any response to short–term variations in traffic flow, vehicles can be delayed for no apparent reason when the road is clear. Unattended sites should not be left in fixed time mode (FT).

FT operation is an automatic mode which is not responsive to vehicle demands. The green time is selected by the ‘maximum green’ switch, and the all–red time is selected by the ‘All–Red’ switch for each phase. The signals will then cycle in a predetermined order at the times selected. Cycle times can only be varied by manual adjustment of the controller.

FT is most applicable when there is a relatively constant flow of traffic on both approaches. It is also applicable when failure of the vehicle detectors prevents use of the vehicle–actuated mode or when a full time operator is not available.

Limitations on use of microwave detectors

Microwave detectors will only register moving vehicles and so, if for any reason a demand is lost, stationary vehicles waiting at the lights can be ignored by the equipment.

A demand can be lost if vehicles are unable to move off a green display. If vehicles do not start to move within 15 seconds of receiving a green display, the controller will terminate the phase and will ignore the waiting vehicles.

To clear these vehicles, it is necessary to either:

- Wait until a new vehicle joins the queue and actuates the detector;
- Change to manual operation (once traffic is running again, the controller can be returned to vehicle–actuated operation); or
- Wait until the controller (or detector) puts in an artificial demand i.e. it is programmed to place such an artificial demand approximately 200 seconds after the phase was last demanded.

Flashing yellow feature

The control equipment automatically switches all yellow aspects to ‘flashing yellow’ within 0.5 seconds when any hazardous or incompatible conditions occur in the operation of the equipment, as required by Transport Specification TSI-SP-049.

In the ‘flashing yellow’ mode, the red and green aspects remain blacked out, and all yellow aspects flash at a rate between 55 and 65 flashes per minute.

If the equipment is allowed to operate for a prolonged period on flashing yellow without a battery change, the signals will eventually turn off.

B.2.8 Operation

Control modes

Although the layout and switch configuration can differ, all controllers have basically the same functions:

- All red – All displays red. Any running sequence is cleared first;
- Manual (MAN) – Control over green displays is via switches or push buttons on the controller. Control can be passed from one phase to another;
- Fixed time (FT) – Control transfers from one phase to the next in a cyclical manner. Each phase receives the green display regardless of traffic flow; and
- Vehicle actuated (VA) – The controller responds to signals from the vehicle detectors. With no demands present the signals will rest in the all-red period.

The mode of operation (manual, vehicle actuated or fixed time) should be selected giving consideration to the operating conditions of the particular site as discussed in more detail in 'Performance'.

Time settings

General

These are shown in *Table B-3.*

Table B-3. General time setting

Mode	Operation	All red	Minimum green	Maximum green	Yellow
MAN/1	*Shuttle*	*M*	*F*	*M*	*S*
MAN/2	*Two-way*	*M*	*F*	*M*	*S*
FT	*Fixed Time*	*S*	*F*	*S*	*S*
VA	*Vehicle Activated*	*S*	*F*	*S*	*S*

Note to Table B-3: *The following abbreviations apply:*

F – Fixed at 15 seconds

M – Set the manual control switch each cycle

S – Needs to be selected and pre-set by the operator for each site

Yellow time

Estimate approach speed. Select the yellow time from *Table B-4*

Table B-4. Yellow time setting

Approach speed	Yellow time
Below 70 km/h	4 seconds

All red time

Measure the distance between the stop lines at each traffic signal. Select an appropriate all-red time from *Table B-5* or *Table B-6* depending on the minimum clearance speed is 20 km/h or 40 km/h respectively.

Maximum green time

Select a maximum green time from *Table B-5* or *Table B-6* depending on the minimum clearance speed. In FT mode, adjust the maximum green times by allowing 3 seconds for each vehicle queued at the end of the all–red period on each approach.

Note: *The minimum setting is 20 seconds.*

In VA mode, the green time will gap off when traffic clears and only run to the maximum if there is no demand for the other phase. If long queues are regularly occurring in one approach, try increasing the maximum green time on that approach only.

Table B-5. Initial signal time settings (low speed)

Distance between stop lines at traffic signals (m)	All red period* (seconds)	Maximum green period (seconds)
0–30	2	30
30–45	5	35
45–75	10	35
75–105	15	40
105–135	20	40
135–165	25	45
165–195	30	45
195–250	40	50
250–310	50	50
310–365	60	60
365–415	70	70
415–465	80	80
465–525	90	90
525–575	100	100

***Note* to Table B-5**: Based on a minimum clearance speed of about 20 km/h.*

Table B-6. Initial signal time settings (high speed)

Distance between stop lines at traffic signals (m)	All red period* (seconds)	Maximum green period (seconds)
0–50	2	30
50–90	5	35

Distance between stop lines at traffic signals (m)	All red period* (seconds)	Maximum green period (seconds)
90-150	10	35
150–210	15	40
210–270	20	40
270–330	25	45
330–390	30	45
390–500	40	50
500–620	50	50
620–730	60	60
730–830	70	70
830–930	80	80
930–1050	90	90
1050–1150	100	100

***Note* to Table B-6**: Based on a minimum clearance speed of about 40 km/h.*

Setting up

The set-up steps given below must be followed and read in conjunction with the manufacturer's requirements:

1. Set up stands with signal aspects facing oncoming traffic
2. Connect controller to the generator and start generator
3. **DO NOT SWITCH CONTROLLER ON**
4. Set red and green times as required
5. Select mode switch
6. Ensure that the shuttle lane or haul road is clear and then switch on controller
7. Controller will serve each phase in turn, clearing the initial demand.

***Note:** Waving a hand smartly toward the detector should place a call on each side for checking VA mode if selected. This will verify that signals are operating properly in this mode even in the absence of traffic.*

Troubleshooting in VA mode

Details are shown in *Table B-7*.

Table B-7. Troubleshooting in VA mode

Problem	Possible cause	Remedy
Long queues	• Green setting too short • Detector fault • Road capacity exceeded	• Increase setting • Call service. • Call supervisor
Signals do change after one stream has stopped even though traffic is waiting	• Detector fault	• Call service. Operate signals in manual or FT mode until service arrives
Green period always same length	• Detector fault • Green setting too short • Traffic flow very light • Traffic flow too heavy	• Call service • Increase green time setting • No action • Call supervisor
Traffic still in shuttle lane at start of opposite green	• Traffic running the red light • All–red setting too short	• Call police • Increase all–red setting
Long gap between last vehicle clearing shuttle lane and start of next green	• All–red setting too long • Detector fault	• Decrease all–red setting. • Call service
Signals do not remain on red in absence of traffic	• Detector fault	• Call service

Examples

Site details

Work area 100 m long in a rural highway situation (see *Figure B-3*):

- Approach speeds 80 km/h;
- Distance between stop lines 160 metres; and
- Minimum clearance speed 20 km/h.

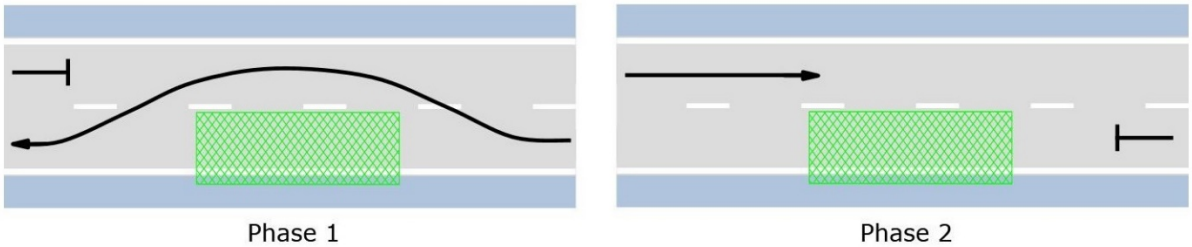

Figure B-3. Illustration of site layout

Example of selecting times for “fixed time” operation

1. From time setting instructions in Maintenance (Transport equipment) and *Table B-4* and *Table B-5*, select initial controller settings:

Table B-8. Initial controller settings

Yellow	**5 seconds**
All-red	25 seconds
Max green:	
Phase 1	45 seconds
Phase 1	45 seconds

2. Switch on and observe for three cycles:

- If all vehicles clear the work area during the all–red period do not adjust “all–red” setting. If vehicles do not clear the work area extend the “all–red” period;
- Count the number of vehicles queued at the end of the all–red period on each approach. Assume the following vehicles queued at the end of the red period:

Table B-9. Number of vehicles queued

	Phase 1	Phase 2
First cycle	10	1
Second cycle	15	6
Third cycle	9	4
Max queued vehicles for three cycles	15	6

3. Adjust “maximum green” times for the two phases:

- Phase 1 – 15 x 3 = 45 seconds;
- Phase 2 – 6 x 3 = 18 seconds (use the minimum setting of 20 seconds).

4. Check regularly that vehicles are not experiencing unnecessary delays due to incorrect settings.

Example of selecting times for “vehicle-actuated” operation

1. From time setting instructions in *Table B-4* and *Table B-5*, select initial controller settings as for FT operation.
2. Switch on and observe for three cycles:

- Check all–red setting as for FT operation;
- Time the green period for each phase using a stop watch. Assume the following green times were measured:

Table B-10. Green times

	Phase 1	Phase 2
First cycle	45	45
Second cycle	45	35
Third cycle	45	30

3. Try extending the maximum green time for phase one by 5 to 10 seconds.
4. If phase one is still running to its maximum green setting, repeat Step 3.
5. Check regularly that vehicles are not experiencing unnecessary delays due to incorrect settings.

B.2.9 Maintenance

General

The equipment should be maintained in good working condition and expendable items, such as traffic signal lamps replaced immediately after they fail. If faults develop, the signals should be taken out of service and alternative traffic control arrangements made. The signals should not be returned to service until the faults have been rectified.

Transport equipment

Maintenance is required on the various items of Transport plant, for example:

- Signal stands, incorporating signal lanterns, vehicle detectors and control equipment;
- Battery packs; or
- Battery charger.

This maintenance is to be addressed under established practice for major plant items. Signal lanterns, vehicle detectors and controllers are to be returned for repair with associated operation and/or maintenance manuals and wiring diagrams to Transport Works Centre as follows:

The Works Supervisor

Transport Services

Traffic Workshop

129A Orchardleigh Street

Yennora 2161

Telephone (02) 9794 4747

Equipment problems, such as faulty wiring that can be corrected in the field may be rectified by a qualified electrician or radio service technician. Expendable items, such as traffic signal lamps and fuses should be replaced in the field and small stocks of such items should be kept in field offices.

Note: *The signal lamps are a special type with quartz envelopes. These quartz envelopes should never be touched with bare hands as they are easily damaged. The lamps should always be held by the metal bases and fitted using cotton gloves.*

B.2.10 Signage

Sight distance on the approach to traffic signals must be 150 m to the primary signal face and the approach speed of traffic must be no higher than 60 km/h. In open road areas where traffic signals might not be expected, a Traffic light symbolic (W3-3) or (T1-30) sign with an __ m (W8-5) sign to indicate distance, should be provided to give advance warning. The position of these signs should take into account the expected queue length from traffic signals and the stopping distance required for heavy vehicles, with this information included in the TMP / and or risk assessment. The STOP HERE ON RED SIGNAL (R6-6) sign must be located 6 m in advance of the portable traffic signal and consideration given to the application of a solid white line (200-300 mm in width) adjacent to the R6-6 extending to the centre of the road. Consideration should also be given to installing a portable VMS on each approach as an additional form of advance warning. An example of a work site layout with PTS is provided in *Figure B-4.*

Additional instructions on the associated signs and use of portable traffic signals are given in *Section 6 Signs and devices*.

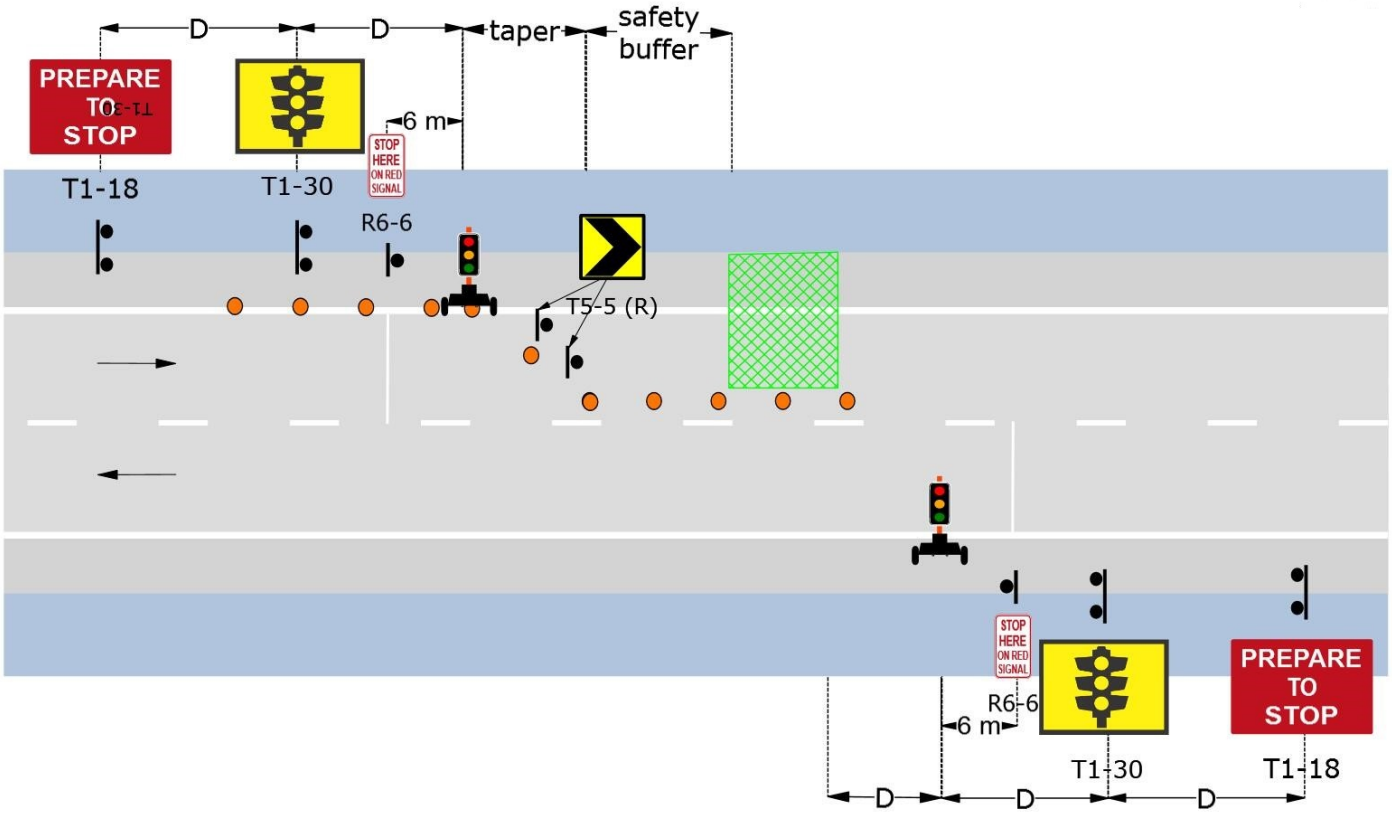

Figure B-4. Example work site layout with PTS

B.3 Usage procedure: Type 1 (manual) portable traffic signal systems

B.3.1 Purpose

This Section supplements the requirements of *Section 6.6.4 Type 1 (manual) portable traffic signal (PTS) systems* and provides the operational requirements for Type 1 (manual) PTS in NSW with or without the use of a boom arm. For the purposes of this manual:

- Type 1 (manual) PTS devices must be approved in accordance with Transport Specification No. TSI-SP-059 Type 1 Portable Traffic Signals.
- Type 1 (manual) PTS devices with a boom arm (Type 1 PTS-B) must be approved in accordance with Transport Specification No. TSI-SP-081 Type 1 Portable Traffic Signals with Boom Barrier.

Reference to Type 1 PTS in this Section includes Type 1 (manual) PTS and Type 1 (manual) PTS-B. This Section must be read in conjunction with the Transport Specification TSI-SP-059 Type 1 Portable Traffic Signals.

B.3.2 Installation and operation

Installation and removal

When installed, Type 1 PTS must be:

- Located where there is a sight distance on the approach to the Type 1 PTS of at least 150m;

Note: *See Table B-2 which provides a guide to stopping sight distances on level bituminous or concrete surfaces.*

- Located in the line of sight of approaching road users, such that all lanterns are clearly visible and unobscured at all times;
- Installed such that they can be securely erected and anchored to prevent excess movement for all likely weather conditions;
- Located at a safe distance from the vehicle travel path, so that loads or turning vehicles will not impact the unit while remaining within the drivers' line of sight;
- Located such that its visibility is not diminished due to the proximity of other warning devices (such as flashing lights) or other plant and vehicles;
- Installed so that the top of the lantern, when erected, is between 2.5 m and 4 m from the surface of the road at the foot of the stand;
- Installed with target boards and visors fitted and in place during operation;
- Installed in accordance with the manufacturer's operation manual and guidelines; and
- Secured so as to not be at risk of being displaced as a result of wind or other disturbance.

When installing a Type 1 PTS, appropriate manual handling techniques should be used in the set-up, pack up and transportation of the device.

At the end of the work shift the Type 1 PTS must be removed from the traffic lane. The PTS must be stored in a safe location outside of the clear zone or behind barriers.

Operation

When installed, Type 1 PTS must be operated by an authorised traffic controller who is trained and competent in the operation of the product. The system must not be left unattended during operation. The authorised traffic controller must maintain direct control of the Type 1 PTS and must do so in accordance with the operating principles and procedures used by a manual traffic controller with a hand held STOP/SLOW bat in single lane operation.

During the operation of a Type 1 PTS:

- Queue lengths and driver behaviour must be regularly monitored and reviewed;
- If adverse driver behaviour is observed, such as swerving, “drive through on red” or end-of-queue incidents, additional control devices such as cones, temporary kerbing or bollards should be installed. These events and any additional controls implemented must be recorded;
- If adverse driver behaviour continues to be observed, the Type 1 PTS must be replaced with an alternative form of traffic control and recorded;
- If two or more traffic controllers are required to operate the system, each traffic controller must be equipped with radio communication;
- Traffic controllers must not use STOP/SLOW signage that may conflict with the Type 1 PTS signage; and
- Items not directly related to the operation of the Type 1 PTS must not be attached to the unit (such as roadwork signage) unless they are in accordance with the relevant specification or approved by Traffic Engineering Services.

Low visibility and night time operation

When operating a Type 1 PTS in low visibility environments such as fog, low light or under night conditions, the area in which it is to be used must be sufficiently lit to ensure the lanterns on the Type 1 PTS do not negatively impact the night time vision of drivers.

When operating Type 1 PTS in night conditions, any potential impacts on night time vision and mitigation strategies must be documented in the Traffic Management Plan and associated risk assessments.

The risk of night time vision deterioration can be dependent on the:

- Exposure time experienced (e.g. short period just driving past or extended waiting for ability to proceed);
- Type of work that is being protected;
- Distances between the lights and the works; or
- Use and placement of other artificial lighting systems (e.g. lighting towers).

B.3.3 Traffic controller requirements

General

All requirements for traffic controllers provided in this document must be complied with.

Risk assessment

In relation to traffic controllers operating a Type 1 PTS, a risk assessment must be conducted to determine the number of traffic controllers to operate the Type 1 PTS.

The risk assessment must also be conducted to determine the safe location of the traffic controller/s in relation to their visual contact with the Type 1 PTS and traffic. See additional requirements below for the location of traffic controllers operating a Type 1 PTS.

Note: *One traffic controller may operate up to two Type 1 PTS devices.*

Location of traffic controllers

Traffic Controllers operating the Type 1 PTS must:

- Be located off the road pavement and out of the travel lane or path of vehicles;
- Have a clear and predetermined escape route;

- Maintain clear visibility of the Type 1 PTS and the front of traffic queues;
- Maintain clear visibility of both Type 1 PTSs and the front of traffic queues for each approach when one traffic controller is operating two barriers; and
- Be located behind a safety barrier where available.

The risk assessment which determines the location of the traffic controller/s must also consider:

- Weather conditions, lighting, road geometry and roadside objects that may obstruct visibility or the escape route of the traffic controller/s;
- Roadside conditions such as long grass or vegetation, uneven and sloping surfaces or other hazards that may be a risk to workers on foot;
- Radio signal range between the PTS remote controls and the traffic signal lanterns; and
- Visual contact of traffic controllers with motorists to encourage compliance.

B.3.4 Signage

Advanced warning must be placed to alert motorists of the Type 1 PTS ahead. Details of the associated signs and use of portable traffic signals are given in *Section 6 Signs and devices*. When the device is not in operation, these signs must be covered or removed. A work type example for the use of a PTCD is provided in *Figure B-4*).

B.3.5 Critical faults

If a critical fault occurs, the Type 1 PTS revert to an all-red display on all lanterns within five seconds. When this occurs traffic controllers and STOP/SLOW bats must be available to perform traffic control for each Type 1 PTS. The traffic management plan must specify the management of equipment and traffic control failures to ensure the ongoing safety of workers and road users.

B.4 Usage procedure: portable boom barriers

This Section supplements the requirements in *Section 6.6.5 Portable boom barriers* and outlines the operational requirements for portable boom barriers in NSW. At the time of publication, there is no Transport specification for portable boom barriers.

B.4.1 Installation and operation

Installation and removal

When installed, portable boom barriers must be:

- Located where the sight distance between the device and oncoming traffic is at least 1.5D;

Note: *A distance of less than 1.5D may be used if a site-specific risk assessment has been undertaken, and documented in the TMP, and the departure is approved in accordance with Section 2.8 Departures from this Technical Manual, with additional measures adopted to ensure traffic controller safety.*

- Located clear of overhead hazards or obstructions;
- Located such that the end of the boom is 500 mm from the edge of the adjoining travel lane;
- Installed such that additional weight can be added to the stability legs via sandbags or other stabilisation methods, if winds greater 50 km/h are expected during operation;
- Installed when there are sufficient gaps in traffic to allow for the predictable and safe lowering of the boom without adversely affecting driver behaviour; and
- Installed in accordance with the manufacturer's operation manual and guidelines.

When installing a portable boom barrier, appropriate manual handling techniques should be used in the set-up, pack up and transportation of the device.

At the end of the work shift, the portable boom barrier must be removed from the traffic lane. The barrier must be stored in a safe location outside of the clear zone or behind barriers.

Operation

When installed, portable boom barriers must be operated by an authorised traffic controller who is trained and competent in the operation of the specific proprietary product. The system must not be left unattended during operation. The authorised traffic controller must maintain direct control of the portable boom barrier and must do so in accordance with the operating principles and procedures used by a manual traffic controller with a hand held STOP/SLOW bat in single lane operation.

During the operation of a portable boom barrier:

- Queue lengths and driver behaviour must be regularly monitored and reviewed;
- If adverse driver behaviour is observed, such as swerving, adverse braking or end-of-queue incidents, additional control devices such as cones, temporary kerbing or bollards should be installed. These events and any additional controls implemented must be recorded;
- If adverse driver behaviour continues to be observed, the portable boom barrier must be replaced with an alternative form of traffic control and recorded;
- If two or more traffic controllers are required to operate the system, each traffic controller must be equipped with radio communication;
- Traffic controllers must not use STOP/SLOW signage that may conflict with the portable boom barrier signage; and
- Items not directly related to the operation of the portable boom barrier must not be attached to the unit (such as roadwork signage) unless it has been approved by Traffic Engineering Services.

Low visibility and night time operation

When operating a portable boom barrier in low visibility environments such as fog, low light or under night conditions, the area in which it is to be used must be sufficiently lit to ensure the visibility of the boom to road users.

B.4.2 Traffic controller requirements

General

All requirements for traffic controllers provided in this document must be complied with.

Risk assessment

In relation to traffic controllers operating portable boom barriers, a risk assessment must be conducted to determine the number of traffic controllers to operate the portable boom barriers.

The risk assessment must also be conducted to determine the safe location of the traffic controller/s in relation to their visual contact with the portable boom barriers and traffic. See additional requirements below for the location of traffic controllers operating a portable boom barrier.

Note: *One traffic controller may operate up to two portable boom barrier devices.*

Location of traffic controllers

Traffic controller/s operating the portable boom barriers, must:

- Be located off the road pavement and out of the travel lane or path of vehicles;

- Have a clear and predetermined escape route;
- Maintain clear visibility of the portable boom barrier and the front of traffic queues;
- Maintain clear visibility of both barriers and the front of traffic queues for each approach when one traffic controller is operating two barriers; and
- Be located behind a safety barrier where available.

The risk assessment which determines the location of the traffic controller/s must also consider:

- Weather conditions, lighting, road geometry and roadside objects that may obstruct visual contact or the escape route of the traffic controller/s;
- Roadside conditions such as long grass or vegetation, uneven and sloping surfaces or other hazards that may be a risk to workers on foot;
- Radio signal range between the portable boom barrier and the remote controls; and
- Visual contact of traffic controllers with motorists to encourage compliance.

B.4.3 T6-6Signage

Advanced warning must be placed to alert motorists of the portable boom barrier ahead. The placing of the sign T1-272n (*Figure B-5* below) must be in accordance with this document. When the device is not in operation, these signs must be covered or removed.

Figure B-5. Portable boom barrier ahead sign (T1-272n)

The STOP sign (R1-1) must be fixed to the boom barrier (see *Figure B-6*), and positioned so that it is vertically and horizontally in the centre of the boom, and is clearly visible to approaching road users.

Figure B-6. Stop sign (R1-1)

Additional instructions on the associated signs and use of portable boom barriers are given in *Section 6 Signs and devices*.

A work type example for the use of a PTCD is provided in *D.4.4 Static: Dual lane closure for work in fast lane - 3 lane / 2 way (formerly TCP 90)*.

B.4.4 Critical faults

If a critical fault occurs, traffic controllers with STOP/SLOW bats must be available to perform traffic control for each portable boom barrier.

The traffic management plan must specify the management of equipment and traffic control failures to ensure the ongoing safety of workers and road users.

B.5 Usage procedure: illuminated flashing arrow signs

B.5.1 Introduction

This Section supplements the requirements in *Section 6.9.2 Illuminated flashing arrow signs* and provides the basic information to effectively use illuminated flashing arrow signs. These signs comprise a matrix of lamps or LED aspects in the form of an arrow that is flashed in a cyclic manner to either the left or right, indicating the direction in which approaching vehicles are to pass.

The equipment is to be operated in accordance with this Section and with the manufacturer's instructions. As part of the daily routine tasks and record keeping, a log must be maintained to record the location and period of display of the signs. This documentation may be required in court in case of an accident or other incident, such as a traffic infringement. Other bodies working on public roads are encouraged to follow these practices where they are applicable. See *Section 8.2 Record keeping of TTM documentation*.

Flashing arrow signs are intended to be applied primarily where a lane is closed or a diversion of traffic is required, typically on a multi-lane carriageway. They may also be adapted for mobile plant operation where only part of the road is blocked by the road plant, but a clear direction to traffic is required as to which side of the plant traffic should pass through the dynamic work site. An example of this is longitudinal linemarking.

Note: *This Section does not replace the field service manual and operating instructions for each set of equipment. It is important that operators are fully acquainted with the manufacturer's instructions and recommendations before attempting to operate the equipment.*

B.5.2 Approvals and specifications

Illuminated flashing arrow signs must comply with the relevant Australian Standards, where they exist, and Transport Specifications TSI-SP-060 Illuminated Flashing Arrow Signs. The relevant Australian Standards are listed in TSI-SP-060. General operating instructions are given in this Section.

Testing of equipment is to be undertaken by the Transport's Intelligent Transport Systems Branch. After type approval has been issued, the manufacturer or selling agent must affix, to the equipment, a durable marking plate in the format provided in *Figure B-7*:

Figure B-7. Marking plate

The number shown on the marking plate must match the number on the type approval certificate issued by the Transport's Intelligent Transport Systems Branch.

Arrangement for copies of the TSI-SP-060 and type approval testing should be directed to:

- "Transport Traffic Equipment and Standards" at ITSHelpdesk@rms.nsw.gov.au;
- A list of current Type Approved equipment can be found in Transport specification TS200 (Register of ITS Field Equipment).

B.5.3 General description of system

Illuminated flashing arrow sign equipment

The following three size designations are used:

- Type A;
- Type B; and
- Type C.

Type A and Type B signs are suitable for mounting permanently on the rear of a road construction vehicle (fixed sign arrangement) or on the cab of a truck or utility vehicle (adjustable sign arrangement). Cab–mounted signs can be rotated to face either the front or the rear of the vehicle. The sign can also be rotated and locked in the face–down position for transport when the sign is not in use. They may be powered from the vehicle's electrical system or from a separate power source.

Type C signs are trailer mounted with integral generator, back–up battery supply and control equipment. Provision is made for the sign to be lowered, rotated and locked for transport or when the sign is not in use.

All signs can operate in one of four modes as detailed in *Table B-11*:

Table B-11. Modes of operation

Mode	Rear monitoring for Type C	Flashing lamps
Arrow right (AR)	– – – – – ■	Shaft and the right-side arrow head
Arrow left (AL)	■ – – – – –	Shaft and the left side arrow head
Double arrow (DA)	■ – – – – – ■ synchronised flash	Shaft and both the left and the right-side arrow heads
Warning (W)	■ – – – – – ■ alternating flash	Pairs of diagonally opposite lamps. Gives a general message of caution or draws attention to an important traffic control sign.

Vehicle-mounted signs

Type A signs are suitable for attachment to light vehicles, such as cars, panel vans or utilities or small plant items. Type B signs are suitable for attachment to heavy vehicles, such as trucks and large plant items.

They are generally used on dynamic works, such as longitudinal linemarking, mobile survey vehicles, patrol vehicles and on shadow trucks protecting groups of workers.

Trailer-mounted signs

Type C signs are self-contained trailer mounted units particularly designed for use on high speed roads, such as rural divided roads where driver expectations are high.

They are generally used at short-term or long-term lane closures for work requiring one or more lanes to be closed for one or more shifts. Where the flashing arrow signs are to operate overnight or over weekends, the associated signs and devices need to be either reflective or lit.

Associated signposting and traffic arrangements

Any additional or associated signposting or traffic arrangements that may be required to be used with flashing arrow signs must conform to the requirements of this Technical Manual.

Using flashing arrow signs tends to downgrade the effectiveness of other devices at the work site so it is essential that the associated signs and devices are in very good condition and special care be taken in their erection. The visibility distance for Type A, B and C flashing arrow signs is 500 m, 1000 m and 1500 m respectively. Associated signs should be located in clear view of approaching drivers, generally on the left side of the road. However, on winding alignment it may also be necessary to erect a sign or signs on the right hand side for clear viewing. Duplicate signs, on the right hand side of the road, may be considered when a driver's view can be obscured by alignment, buildings or heavy traffic. The use of larger signs may be considered for high approach speeds.

B.5.4 Equipment installation

Lamps

The brightness of the lamps is adjusted by an automatic dimming control which dims the light output for night conditions. A photocell detects the ambient light conditions that trigger the dimming facilities.

The flash rate for flashing arrow displays (AL, AR, and DA) can vary from 50 to 60 per cent on–time and 50 to 40 per cent off–time. For diagonal flashing displays (W), the on–time and off–time is the same. The repetition rate for all modes is between 35 and 40 cycles per minute.

Two monitoring lamps are provided at the rear of the Type C sign to allow workers to monitor the mode of operation. These lamps flash as shown in *Table B-11*.

Sign boards

Generally, the flashing arrow sign unit should be positioned as near as possible in the driver's line of sight. It is important to always locate signs to give the driver maximum visibility and time to understand and react to the sign message. The visibility distance of the sign i.e. the distance at which the motorist can first become aware of the flashing arrow, varies as shown in *Table B-12*. The minimum sight distance that should be provided to the flashing arrow sign depends both on the vehicle type and vehicle speed in the approach to the work area.

Table B-12 provides a guide to the sight distances appropriate for the three types of sign. On high speed roads, every effort should be made to position the sign to achieve the desirable minimum sight distance:

Table B-12. Typical sight distance for placement of flashing arrow signs

Sign type	Visibility distance (m)	Sight distance	
		Desirable minimum	Absolute minimum
A	500	250	150
B	1000	500	300
C	1500	750	450

Note to Table B-12: *Increase the sight distance by 2% for each 1% of downgrade. Decrease the sight distance by 2% for each 1% of upgrade.*

The signs must be securely erected and anchored to prevent wind movement or interference by vandals. This is especially true for Type C signs as these are intended to be operated unattended.

The signs must also be aimed carefully to direct their display to the approaching vehicles. It is important that the sign be aimed to vehicles within the 'critical zone' which covers the distances where drivers have time to react to the message and change lanes or stop if necessary. This is particularly important if the approach alignment of the road is not straight.

Sighting is usually done by means of a 'sighting' device which facilitates aiming of the sign display. Such an aiming device must be substantially free of parallax error and must make allowance for the inherent downcast in the sealed–beam lamps. In the absence of a 'sighting' device fitted to the sign, aiming needs to be undertaken by "trial and error".

Table B-13 lists the recommended aiming distances from the sign near the start of the taper defining the lane closure:

Table B-13. Aiming distances for various approach speeds

Approach	**Aiming distance (m)**		
speed (km/h)	sign type		
	A	B	C
less than 60	60	120	180
60	100	200	300
80	140	280	420
100	200	400	600
greater than 100	260	520	780

Note 1 to Table B-13: *The aiming distance should not exceed the sight distance.*

Note 2 to Table B-13: *The recommended aiming distances for the Type A sign is based on the stopping distance plus the reaction distance for 2.5 seconds of travel PLUS an allowance of 30 metres for siting the sign past the start of the taper*

Note 3 to Table B-13: *The aiming distances for Type B and C signs are two and three times of those for the Type A sign to take advantage of their greater size and visibility*

Note 4 to Table B-13: *Type C signs are not usually used on low speed roads.*

Figure B-8 is an illustration of aiming and sight distance, showing the relationship between these two distances used when setting up flashing arrow signs.

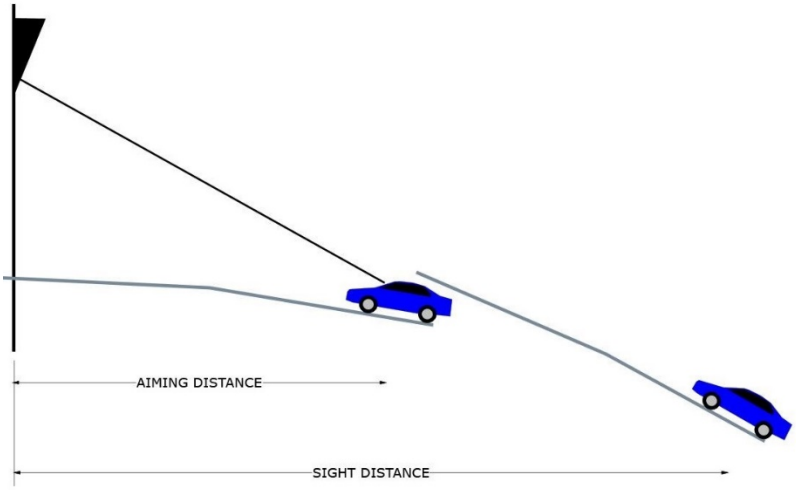

Figure B-8. Illustration of aiming and sight distance

Controls

The controls available are:

- Power: On/Off;
- Mode selection; and
- Mode monitoring (Type C signs only).

B.5.5 Operation

Control modes

Although the layout and switch configuration can differ, all controls have basically the same functions, namely:

- Arrow Right (AR);
- Arrow Left (AL);
- Double Arrow (DA); and
- Warning (W).

Flash rate

The flash rate is fixed to the levels given in the specifications and cannot be varied. It is important to check that all lamps are functioning to give the correct display selected by the controls.

Dimming

The dimming facilities are automatic, but care should be taken that any incident light from street lighting or vehicle headlights falling on the photocell does not adversely interfere with the operation of the dimming feature. The photocell should be occasionally cleaned to maintain brightness.

Setting up

The equipment should be set up to the manufacturer's instructions with particular care to the siting and aiming of the signs to suit the layout arrangement being used and the geometry of the road approach to the sign.

Troubleshooting

The monitoring lamps should be regularly observed to confirm that the sign is operating in the appropriate mode for the work site. It is also necessary to regularly inspect the front panel of the sign to ensure that all lamps are clean and alive.

If one lamp is not operating, check it and if it is blown, replace it with a new lamp. If all lamps are out or all lamps are too dim for the conditions, check the battery or generator for charge. If the charge is satisfactory, but the lamps are still too dim for the conditions, check the photocell is not being blocked from reading the true ambient light level.

B.5.6 Maintenance

Field service

Operators should familiarise themselves with the manufacturer's instructions. A high level of field service is essential to maintain the sign in good condition to provide an effective warning to motorists at all times.

Field service usually covers:

- Simple fault diagnosis and associated replacement of the faulty modules;
- Routine maintenance and servicing including replacement of lamps and other consumable components; and;
- Keeping the equipment clean and tidy.

These requirements are detailed in the manufacturer's instructions.

Major repairs

If major faults develop, the sign should be taken out of service and alternative traffic control arrangements made. The sign should not be returned to service until the faults have been rectified.

Administration procedures

See local office procedures in respect of administration, costing and maintenance of flashing arrow signs as an item of small plant.

B.5.7 Signage

Instructions on the use of illuminated flashing arrows are given in *Section 6.9.2 Illuminated flashing arrow signs.*

The following three sign size designations are used:

- Type A – 1260 mm by 650 mm for roof mounting on light vehicles;
- Type B – 1500 mm by 770 mm for cab mounting on trucks; and
- Type C – 2400 mm by 1200 mm for trailer mounting and using its own power source or cab mounting on a truck.

High intensity flashing lamps may be used in conjunction with this sign provided that the lamps are either appropriately shielded or laterally or vertically displaced from the edge of the sign to avoid visually corrupting the arrow shape or its directional effect.

Requirements for the flashing of different patterns of the lights are:

- When traffic is expected to pass the sign on a particular side and can do so in safety, i.e. it is not required to seek a gap in oncoming traffic, the bar of the arrow and the barb directing traffic to that side must be flashed; and

- When the sign is used to give a general warning of works activity ahead, including dynamic works, but either the sign is located clear of the traffic path or the display of an arrow would not be appropriate for some other reason, the four corner lights at the extremities of the barbs must be flashed with diagonal pairs flashing alternately.

Additional instructions on the associated signs and use of illuminated flashing arrows are given in *Section 6 Signs and devices*.

B.6 Usage procedure: temporary portable rumble strips

This Section supplements the requirements outlined in *Section 6.11 Temporary portable rumble strips (TPRS)* and details the operational requirements for temporary portable rumble strips (TPRS) in NSW. At the time of publication, there is no Transport specification for TPRS.

B.6.1 Installation and operation

Placement, installation and removal

To protect oncoming traffic from the risk of swerving behaviour TPRS must be placed in one of the following methods:

1. Where traffic is reduced to and controlled within a single lane; or
2. On a 2-lane 2-way road where a temporary median kerb with delineators is installed on the centreline for a distance of D prior to the first strip in each array.

Where placed on a 2-lane 2-way road, where a temporary median kerb with delineators, the median kerb delineators must be installed:

- Commencing immediately adjacent to the first TPRS;
- Extend a minimum distance of D prior to the TPRS; and
- Have spacing of not greater than 18 m between the centres of each section of kerb.

Example work site layouts for shuttle flow and merge lane closure scenarios using a TPRS are provided in *D.4.10 Static: Use of temporary portable rumble strips (shuttle flow)* and *D.4.11 Static: Use of temporary portable rumble strips (merge lane closure)*.

Additional examples of work site layouts for TPRS on approach to work area are provided in *Figure 6-34* and *Figure 6-35*.

When installed, TPRS must:

- Be located away from and not adjacent to, workers on foot;
- Be located at least four seconds of travel time after a driver decision point, driver action point or another TPRS array;
- Be located at least 30 m away from the work area;
- Be visible to an approaching road user for at least a distance of D metres; and
- Be installed in accordance with the manufacturers operation manual and guidelines, however, in case of a discrepancy, the requirements of this Technical Manual prevail.

When located on a designated cycle path, a minimum 1 m shoulder adjacent to the TPRS must be provided. If this is not possible, other safe alternative provisions must be made.

If the length of the work area is greater than 200 m, or there is an interrupted line of sight between each end of the work area, then intermediate TPRS arrays and their associated signing should be installed at intervals of not less than 100 m.

When installing TPRS, appropriate manual handling techniques should be used in the set-up, pack up and transportation of the device.

When the work site is unattended or a speed limit of greater than 65 km/h is reinstated, TPRS must be removed and associated signs (T5-210, T5-211) removed or covered up.

Operation

During the operation of TPRS:

- Regular monitoring and review of the TPRS must be undertaken to monitor movement and driver behaviour;
- If adverse driver behaviour is observed, such as heavy braking or swerving on approach or around the TPRS, additional controls such as increasing the TPRS sign's advance warning distance should be implemented;
- In the event of swerving behaviour, the installation of additional control devices such as cones, temporary kerbing or bollards, should be implemented in consideration of OSOM vehicles; and
- If adverse driver behaviour continues to be observed, TPRS must be replaced with an alternative form of traffic control and recorded.

Low visibility and night time operation

When TPRS are operating in low visibility environments such as fog, low light or under night conditions, the area in which each array are being used must be sufficiently lit to ensure the visibility of the TPRS to road users.

Movement

TPRS are not secured to the road surface and as such, movement of the devices is possible. Factors influencing the degree of movement include:

- Type of road surface;
- Grade;
- Traffic composition; and
- Volume.

Regular inspections for TPRS movement must be carried out during operation.

Inspections should be completed more frequently when:

- Using TPRS at a work area for the first time;
- Used on grades;
- Used under high volumes of traffic; or
- Used under a higher proportion of heavy vehicles.

Maximum movement tolerances for TPRS are provided below in *Figure B-9* to *Figure B-11*, and if movement exceeds these tolerances, or if the TPRS becomes disconnected, it must be rectified immediately.

To assist in identifying the extent of movement, a method of determining placement should be employed, such as using a chalk mark or aligning with a landmark to indicate where the TPRS were placed.

The frequency of remediation of displaced or disconnected strips must be monitored and risk-assessed. If it is determined that the frequency and risk of remediation exceeds the benefit gained by the use of the TPRS, the TPRS must be removed.

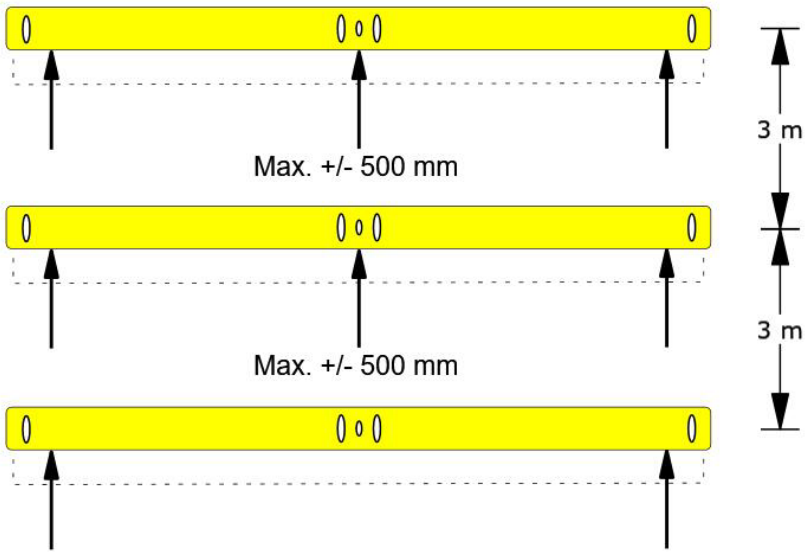

Figure B-9. Maximum movement tolerance for TPRS - Longitudinal movement

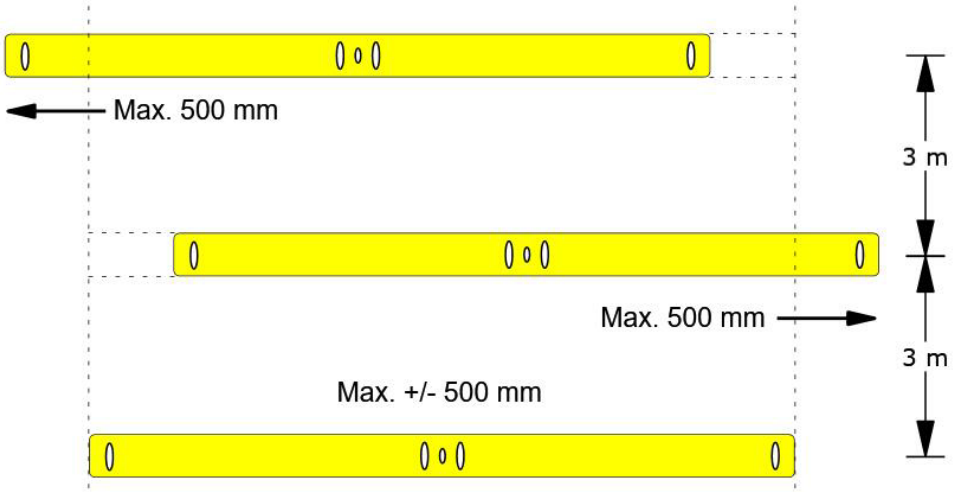

Figure B-10. Maximum movement tolerance for TPRS - Lateral movement, sideways

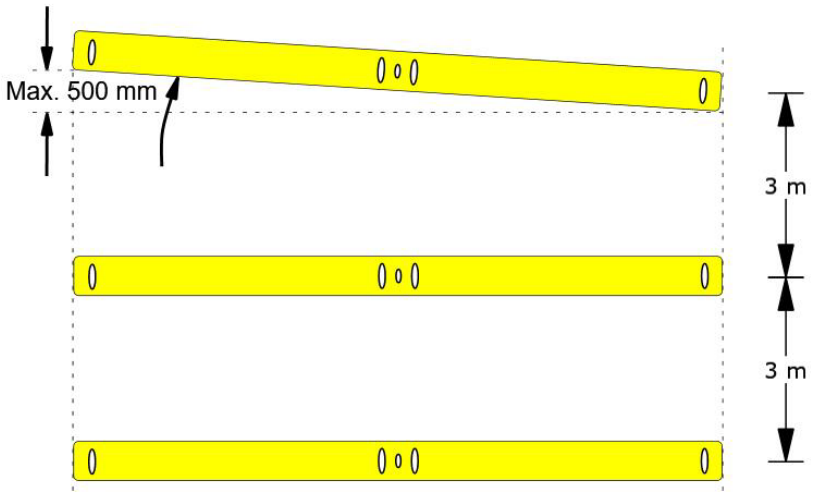

Figure B-11. Maximum movement tolerance for TPRS - Skewing / rotation

B.6.2 Signage

Warning signs must be installed to alert drivers to the use of TPRS.

TPRS must be used with the following signage:

- A Speed hump ahead symbolic (*Figure B-12*) warning sign installed at distance D before the first rumble strip. The distance may be increased to 1.5D – 2D when there is poor compliance or adverse driver behaviours, such as excessive speed or harsh braking; and
- A Speed hump symbolic (*Figure B-13*) warning sign placed next to the first strip at a TPRS array.

When using TPRS with a temporary median kerb and delineators the following additional signage must be installed:

- A temporary collapsible chevron delineator (T5-7) on the first temporary median on approach to the TPRS (see *Figure B.14*); and
- A NO OVERTAKING sign (W8-240n) must be installed at distance 1.5D before the first rumble strip in advance of the temporary median (see *Figure B.15*).

Figure B-12. T5-210 Speed hump ahead sign

Figure B-13. T5-211 Speed hump sign

Figure B-14. T5-7 Chevron delineator

Figure B-15. W8-240n No Overtaking

When the work site is unattended or a speed limit of greater than 60km/h is reinstated, TPRS must be removed and associated signs, (*Figure B-13*) and (*Figure B-12)* removed or covered up.

A Variable Message Sign (VMS) may be used to further alert drivers of TPRS if adverse driver behaviour is identified. The addition of VMS should be considered as part of the development of the TMP and included by the designer as part of the TGS.