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KERAJAAN MALAYSIA
JABATAN KERJA RAYA MALAYSIA

STANDARD SPECIFICATION FOR ROAD WORKS

Section 8: Traffic Signal System



CAWANGAN KEJURUTERAAN JALAN DAN GEOTEKNIK,
IBU PEJABAT JABATAN KERJA RAYA,
TINGKAT 22, MENARA TUN RAZAK,
JALAN RAJA LAUT,
50350 KUALA LUMPUR.

KETUA PENGARAH KERJA RAYA,
JABATAN KERJA RAYA MALAYSIA,
JALAN SULTAN SALAHUDDIN,
50582 KUALA LUMPUR.

FOREWORD

As practices in road construction change over time, it is imperative for Jabatan Kerja Raya (JKR) to continuously update and improve their standard specifications. These new specifications are not only aimed at keeping abreast with current technologies but also helping in improving the quality of constructed product. In unison, these new specifications have a significant positive impact on the construction industry especially with the incorporation of new products and technologies.

Standard Specification for Road Works is an essential component in the road infrastructure construction industry. This specification provides an improved guidance in the material selection and the production of good quality workmanship and products, based on current best practices. The purpose of this standard specification is to establish uniformity in road works to be used by road designers, road authorities, manufacturers and suppliers of road related products.

This document "Standard Specification for Road Works - Section 8: Traffic Signal System" is a part of a series of improved specifications in the Standard Specification for Road Works. The compilation of this document was carried out through many discussions by the technical committee members. Additionally it has been reviewed by a group of independent consultants and presented at a technical workshop held on 15 – 17 July 2008. Feedbacks and comments received were carefully considered and incorporated in the specification where appropriate.

ACKNOWLEDGEMENT

This **Standard Specification for Road Works - Section 8: Traffic Signal System** has been prepared by a technical committee consisting of Civil and Electrical engineers from Cawangan Jalan & Geoteknik, Cawangan Kerja Elektrik and State JKRs. The members of the committee involved in preparing this Standard Specification for Road Works - Section 8: Traffic Signal System are:-

Committee Members

Ir. Hj. Abdul Rahman B. Baharuddin (*Chairman*)	Cawangan Kej. Jalan & Geoteknik
Pn Sabariah Bte Hussain (*Deputy Chairman*)	Cawangan Kerja Elektrik
En. Rijal Nazli B. Sulaiman	Cawangan Kej. Jalan & Geoteknik
En. Shahrul Affendy B. Abu Bakar	Cawangan Kerja Elektrik
En. Abdull Latif B. Sulaiman	Cawangan Kerja Elektrik
Pn. Siti Nor Binti Hassan	Cawangan Kerja Bangunan Am.
Pn. Noor Fadzilah Bte Ramlee	Cawangan Kerja Elektrik.
En Nooru Alam B. Hj Ambak	JKR Elektrik Kedah
Pn. Rozina Bte Sudin	JKR Elektrik Perak
Pn Maznida Shahila Bte Mat Salleh	JKR Elektrik Negeri Sembilan
Pn Siti Norleha Bte Rasid	Cawangan Kej. Jalan & Geoteknik
En Mat Rodi B. Junoh	Cawangan Kej. Jalan & Geoteknik

The Committee would also like to thank our colleagues at JKR especially the staffs from Bahagian Keselamatan Jalan (Caw. Kej. Jalan & Geoteknik) who have assisted and contributed towards the successful completion of this specification.

SECTION 8 - TRAFFIC SIGNAL SYSTEM

8.6 TRAFFIC CONTROLLER

8.7 VEHICLE DETECTORS

8.8 ROAD WORKS

SECTION 8 - TRAFFIC SIGNAL SYSTEM

8.1 GENERAL

8.1.1 Scope of Work

This work shall comprise the design of cabling works prior to construction, supply and installation of all signal lanterns, traffic controllers, detectors, posts, ducting and cabling, and switchgears with all necessary ancillary equipment, together with the transportation, storage, erection, connection, testing and commissioning of the same for a complete traffic signal installation, all in accordance with the Drawings and this Specification. The work shall also include cabling from the nearest specified power source of the local supply authority to the traffic control system, if required.

The type of signal operation, number of plans, number and sequence of phases, cycle times, timings of each phase, offset times, locations of controllers and power source tapping points, and other specific requirements shall be as shown on the Drawings.

In the case of 'Design and Build' or 'Build-Operate-Transfer' (B.O.T.) type projects, the traffic signal shall be designed in accordance with the latest Arahan Teknik (Jalan) on the design of traffic signals. The Tenderer shall obtain the signal operation requirements from JKR prior to designing the traffic signal system.

8.1.2 Design and Construction

8.1.2.1 Contractor's Responsibility

The Contractor shall design the interconnecting signal cabling for the proposed signal system as shown on the Drawings. The cabling design drawings are to be approved by the Superintending Officer (S.O.) before construction commences. Equipment offered shall be in all respects suitable for the requirements and for the environmental conditions specified. The Contractor shall be responsible for the design, material quality and workmanship of the system and every part of the system offered, whether manufactured by him or supplied to him by other manufacturers. Approval by the S.O. does not relieve the Contractor of these responsibilities.

Materials shall as far as possible be of Malaysian origin except where such materials can be shown to be unavailable in Malaysia.

The Contractor shall provide relevant training on the system installed for the S.O. and JKR operational staff.

8.1.2.2 Cleanliness

Particular attention shall be given in the design of the equipment for the exclusion of dust, dirt, etc., especially in the case where forced ventilation is employed.

8.1.2.3 Metric Range of Preferred Dimensions

Except as may be agreed for practical reasons, design shall make use of the metric range of preferred dimensions and tolerances.

8.1.2.4 Self-Tapping Screws

Self-tapping screws shall be used only for retaining duties. They shall not be used for fixing removable covers, nor for the support of direct loads.

8.1.2.5 Corrosion

All equipment shall be able to resist corrosion in the Malaysian environment for a period of 10 years from the date of installation.

8.1.2.6 Compliance With Manufacturer's Instructions

The Contractor shall ensure that the equipment and parts used shall be entirely suitable for the work to be performed and that they shall be manufactured to proper tolerances and fit. He shall further ensure that the loading of equipment shall under all normal circumstances not exceed the maximum laid down or agreed to in writing by the manufacturer.

The Contractor shall be responsible for the inspection of all equipment and parts before their incorporation in the Works to ensure that they comply with the requirements of this Specification and that they are not defective in any way as regards materials or workmanship. Should any such non-compliance or defects be found during the inspection, the Contractor shall correct or cause to be corrected such non-compliance and defects, all at the Contractor's expense and to the satisfaction of the S.O.

8.1.3 Components and Materials

8.1.3.1 Conditions of Operation

The system shall be designed to operate continuously. Account shall be taken of equipment being sited in all exposed locations.

8.1.3.2 Maintenance

In the event of system failure due to breakdown or accident, the contractor shall take immediate action in identifying and rectifying the problem at site.

The contractor shall warn the motorist by placing warning signboards on traffic signal posts at all approach roads to avoid confusion and unwanted incidents. The contractor must attend the breakdown within the response time set by the authorities.

The Contractor shall ensure that the materials and components, excluding consumable items such as lamps, shall have 10 years life expectancy warranty from the manufacturer. Components which have a shorter life span but are easily replaceable may be accepted with the approval of the S.O.

8.1.3.3 Components

All active and passive components, their mounting and the plugs, sockets and connections, shall be designed for a life expectancy of 10 years as specified in Sub-Section 8.1.3.2. All shall operate well within their ratings with due consideration for the environmental conditions and temperature rises within cabinets or enclosures.

8.1.4 Identification of Equipment

The Contractor shall mark or label clearly all modules, units and main parts of the system with a functional code or title, type number, trade name and serial number. The marking or labeling of main items shall be clearly visible on the outside. The labels and markings of encased units or modules shall be visible when the case or cover is removed. Components shall not be marked with circuit references. The marking shall be adjacent to the component. Markings required for controls, maintenance or warning shall be adjacent to the part concerned. Markings shall maintain legibility throughout the life of the equipment in the specified environmental conditions.

Techniques used shall be approved by the S.O.

8.1.5 Protective Requirements

8.1.5.1 General

All metal work not normally required to carry current shall be connected to an earth point except where otherwise dictated by transmission or other requirements (such metal work shall include cases, screens, cores, cable glands, cable conduits and cable sheaths, etc.).

8.1.5.2 Insulating Bushes

Insulating bushes shall be provided wherever conductors carrying dangerous voltages pass through holes in metal parts and where the conductors would be likely to touch the edge of the holes.

8.1.5.3 Isolation from Main Supply

Unless otherwise agreed by the S.O., systems shall be completely isolated from the mains supply by means of a suitable double-wound transformer which shall include an earthed screen. The primary and secondary output terminations shall be separated in an approved manner.

The main transformers at the controller shall be provided with primary tapping so that the equipment operates with mains supply in the range of 200 to 260 volts.

8.1.5.4 Earthing of Transformer Secondary Circuits

When a dangerous voltage is connected to the primary winding of a transformer, the secondary circuit shall be connected where practicable to an earthed point.

8.1.5.5 Current Loading of Wires

All wirings shall be suitably rated to carry in excess of the current permitted by their fuses, circuit breakers or other current linking devices. Similar precautions shall be taken to reduce the possibility of overheating components.

Provisions shall be made in the equipment:-

a. to prevent damage to circuits due to failure of any pulses, power supplies or mains supply;
b. to prevent damage to power supplies by inadvertent removal of the load.

8.1.5.6 Danger Notices

All equipment or units working at a voltage at or above 150 volts D.C. or 100 volts A.C. (RMS) shall be protected by an approved cover, which shall be removable. The cover shall have a sign with a danger symbol indication of the voltage. The highest voltage to which access can be had by removal of the cover shall be shown, where dangerous voltages exist.

8.1.5.7 Cable Connecting Units

Terminal strips and terminals shall be clearly and indelibly coded. Terminals carrying mains electrical power shall be segregated from other terminals. Unless approved by the S.O., not more than three cable cores shall be retained by any terminal. All wiring and cabling shall be neat, adequately supported to prevent vibration, and so arranged as to prevent strain on individual wires, particularly on hinged panels.

8.1.5.8 Insulation

If no value is specified, the insulation resistance between any two parts not intended to be in electrical contact shall not be less than 100 Mega ohms when measured at a voltage appropriate to the equipment.

8.1.6 Electricity Supply

The Contractor shall obtain an exclusive electricity supply from local power supply authority for the traffic signal system without sharing with other services such as street lighting, Variable Messaging System, etc.

The Contractor shall comply with the local power supply authority requirements in getting an electricity supply to the installation, and any costs associated with obtaining this supply shall be included in the Tendered rates. The Contractor shall ensure that the equipment supplied will function correctly at the supply voltage, and shall allow for normal variation and surges.

8.1.7 Testing and Commissioning

Upon completion of the installation work on site and before the Certificate of Practical Completion is issued, the Contractor shall arrange for all necessary tests to be carried out on the installation by competent person as part of the tests required of him under this contract. The cost of these works is deemed to be included in the contract.

The S.O. reserves the right to be present during testing and commissioning.

The Contractor shall notify the S.O. when the tests are to be carried out. The S.O. reserves the right to be present during testing. The Contractor shall forward to the S.O. duly certified copies of the test results when the tests have been successfully completed. If the S.O. decides the system is not in accordance with the Contract, he may reject the system, and he shall inform the Contractor of the reasons in writing.

The Contractor shall provide appropriate temporary sign during testing and commissioning of the traffic signal system.

Upon satisfaction of the system, the S.O. shall notify the Contractor the date for the commissioning of the traffic signal system.

8.1.8 Documentation

8.1.8.1 As-Installed Drawings, Manuals And Tools

Within one calendar month after the practical completion of the project, four sets of prints (ISO A3 size) for each of the following drawings shall be submitted :-

a. Site plan
b. Schematic Wiring Diagrams and Control Circuit Drawings
c. Traffic Signals Layout Plans
d. Layout plans of cable routes and earthing points, with reference to easily recognizable landmarks, buildings and structures. The plans shall also show the final wiring diagrams, post locations, controller locations, detector placement (loops and pits), galvanised iron (G.I.) ducts and timing plan.

The as-installed drawings shall also be stored in Compact Disc or any other electronic media as specified which can be readily retrieved by computer. The software programme shall be AutoCAD of a release specified or of the latest release.

In addition, four sets of the following manuals/brochures and documents, suitably bound, shall be submitted to the S.O.:

a. Installation Manual
b. Operation Manual
c. Service and Maintenance Manual
d. Parts List
e. Product Data and Catalogues
f. Product Test Certificates
g. Inventory Listing and Assets Tagging

These drawings shall have at the lower right corner the Contractor's name and address, date of commissioning, scale, drawing number (the drawing number shall be obtained from the S.O.), title and the following particulars:-

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CONTRACT NO:
TENDER NO:

If the drawings submitted are not acceptable to the S.O., the Contractor shall amend and resubmit the drawings within two weeks from the date of notification by the S.O.

A set of A4 size schematic drawings and layout plans shall be laminated and placed inside the pocket of the controller. Special tools required for the operation, service and maintenance of the controller and switchgear, post and other equipment shall also be provided. The cost of all these prints, manuals and tools shall be deemed to be included in the Contract.

Great care shall be taken to ensure that in the writing of all documentation, expert familiarity with apparently simple features is not advertently assumed. Difficulties should be anticipated.

All documentation shall be in English or Bahasa Melayu.

8.1.8.2 Hardware, Software and Maintenance Manual

The manual shall contain descriptions of the complete hardware system followed by maintenance procedures. A description of the complete software system shall also be included.

The hardware description shall start with the overall configuration of the system, with layouts showing the location of every unit, with block diagrams and an explanation of the operation of the system.

Detailed descriptions of component units shall explain their operation. Block diagrams showing the flow and interaction of data, logic diagrams, circuit diagrams with component valves, and layout diagrams shall be provided. Parts lists and wiring schedules shall be provided, but care shall be taken to avoid these obscuring the operational description. Maintenance procedures shall cover the diagnosis of faults, testing and setting up adjustments, replacement of units and routine mechanical servicing.

The software description should aim at enabling new programs for an intersection to be written, and to provide the basic standard techniques used in writing the system programs. Where programming technique is dependent on particular features of the system, it is important that program material is specially written. This shall be in the form of guidance, referring to operational features in the software manual.

8.1.9 Guarantee of Supply

The Contractor shall be required to ensure that for a period of not less than 10 years from the date of commissioning the system, a supply of replacement components and materials or their agreed equivalent is available, as the S.O. may require. A Contractor who is not a manufacturer is required to submit a letter from the manufacturer certifying that the manufacturer will support the equipments and components.

8.1.10 Warranty Period

After acceptance of the installation, the Contractor shall still be subject to obligation of free servicing, change in phasing, maintenance and free replacement of all defective parts and fused bulbs for a period of twelve (12) months from the date of issue of the Certificate of Completion. A qualified Engineer provided by the Contractor must be available on 24 hours service a day to attend to any breakdown at anytime including public holidays.

All repairs and replacements required during the Warranty Period shall be carried out with dispatch and an adequate supply of spares shall be available for this purpose. The Contractor shall be liable for damages if he does not undertake remedial works within 24 hours.

The Contractor shall carry out any repair within 24 hours of being informed of the damages. Upon failure to do so, the S.O. has the option to appoint another party for repair and the cost thus incurred will be borne by the Contractor.

All maintenance conducted shall be entered into the Local Controller Logbook, dated and signed by the maintenance staff of the Contractor.

Repainting of the signal posts shall be performed just before the end of the Defect Liability Period, if necessary.

8.2 LOW VOLTAGE UNDERGROUND CABLES

8.2.1 Types of Cables

8.2.1.1 Power Cables

Power cables shall be PVC/SWA/PVC cable as specified in Appendix 8A (L-S3: Specification For Low Voltage Underground Cable, Cawangan Kejuruteraan Elektrik JKR).

8.2.1.2 Feeder Cables for Vehicle Detectors

Feeder cables to vehicle detectors shall be PVC/SWA/PVC cable as specified in Appendix 8A (L-S3: Specification For Low Voltage Underground Cable, Cawangan Kejuruteraan Elektrik JKR).

8.2.1.3 Loop Cables for Vehicle Detectors

The material for inductive type vehicle-detector loop cables shall be in accordance with A.S. 2276.3 or unless otherwise specified herein. The Loop cables shall be of a type which can be easily assembled from bulk cable on site, and shall be approved by the S.O.

8.2.1.4 Earthing System

The earthing system shall comply with the requirements of MS IEC 60364 as specified in the Drawings.

The earthing conductors shall be 25mm x 3mm copper tape and the earth electrodes shall be of copper-jacketed steel core rods with 16mm diameter and supplied in 1500mm length. The copper jacket of 99.9% purity electrolytic copper shall be of minimum radial thickness 0.25mm and shall be molecularly bonded to the steel core to ensure that the copper jacket and steel core are non separable. Each earth electrode shall be driven 3000mm in depth. Where the desired earth resistance value cannot be achieved after the first earth electrode have been driven, sufficient number of the electrodes in parallel shall be installed outside the resistances area until required value is reached.

The connection of the earthing conductor and/or the earth electrode shall be soundly made by the use of plumbed joints, either by brazing using zinc-free material with a melting point of at least 600°C or by thermic welding or by cold pressure welding.

The inspection chamber shall be made of heavy duty pre-cast concrete of minimum 300mm (L) x 300mm (W) x 210mm (H) complete with removable concrete cover.

8.2.2 Cable Termination

Unless otherwise permitted, all cable termination and jointing works shall be carried out in the presence of the S.O.

Power and feeder cables shall be terminated as specified in Appendix 8A (L-S3: Specification For Low Voltage Underground Cable, Cawangan Kejuruteraan Elektrik JKR).

Loop cables shall be terminated using appropriate cable connector.

8.2.3 Cable Jointing

No cable jointing shall be allowed for interconnecting signal cables. Jointing of mains power cables shall be allowed only when approved by the S.O.

8.2.4 Cable and Detector Pit

All cables between poles, loop detectors and traffic signal controller shall be fully installed in galvanized steel pipes and cable pits. The galvanized steel pipes shall be of heavy duty type, complying with BS 1387 and complete with screwed and socketed joints.

The cable pit shall be of heavy duty pre-cast concrete pit with a minimum size of 450 mm (L) x 450 mm (W) x 450 mm (H) unless otherwise specified. The cable pit shall also act as a cable marker.

Detector pit shall be 300 mm (L) x 300 mm (W) made of heavy duty pre-cast concrete pit unless otherwise specified.

8.3 SIGNAL LANTERNS / HEADS

8.3.1 Standard Requirements

All components, their installation and performance, shall be in accordance with BS EN 12368 unless otherwise specified herein.

8.3.2 Optical Requirements

8.3.2.1 Optical Arrangement for Drivers

Each signal face shall, unless otherwise shown on the Drawings, contain three optical systems arranged vertically, each having a nominal diameter of 300mm.-The coloured lenses of the upper optical system shall be red, the middle one amber, and the lower one green.

Signal heads shall be fitted with a type A visor.

8.3.2.2 Optical Arrangement for Pedestrians

Each signal face shall contain two optical systems arranged vertically, each having a nominal diameter of 300mm as shown in the Drawings. The upper optical system shall consist of either one of the followings:-

a. a double digit countdown unit with amber LEDs and red symbolic waiting pedestrian or
b. an illuminated "TUNGGU/LINTAS" indication with a green symbolic walking pedestrian for the lower optical system.

8.3.3 Height of Signal Head

8.3.3.1 Post-Mounted Signal Head Intended For Drivers

The height of signal head shall be such that when erected the centre of the green optical system shall be 2.5m above the carriageway level.

8.3.3.2 Signal Head Intended For Pedestrians

The height of signal head shall be such that when erected the centre of the green optical system shall be 2.5 m above the carriageway level.

8.3.3.3 Overhead Mounted Signal Head

The height of overhead mounted signal head shall be such that when erected, the lowest point of the signal head assembly shall be not less than 5.5m or more than 6.5 m above the carriageway level.

8.3.4 Lamps

8.3.4.1 Halogen Lamp

The lamp used in the optical system, to meet the requirements of A.S. 4113 Part 2 shall be a 10 V, 50 W, long life tungsten halogen lamp.

The bulb shall be clear, uncoloured and the filament shall only be used in the horizontal position. The lamp shall meet the following requirements as tested in A.S. 4113 Part 2:

- TABLE 8.3.1: CHARACTERISTICS OF HALOGEN LAMP

Characteristics	Values
Nominal lumens	820 lm at 10V
Nominal life	6000 hours continuous burning at 10V input
Nominal colour temperature	2850 K at 10V input

Each tungsten halogen lamp shall be provided with an appropriate transformer complying with the requirements of B.S. 9720, mounted within the signal head and connected to a terminal block which may be mounted remotely. Wiring between the lamp holder and the transformer and the terminal block shall be in compliance with the requirements of M.S. 136 and B.S. 6007.

8.3.4.2 LED Signal Module

Each module shall consist of an assembly that utilizes LEDs as the light source in lieu of an incandescent lamp for use in traffic signal system. The LEDs shall utilize appropriate latest technology to achieve the required colour and shall be the ultra bright type rated for 100,000 hours of continuous operation from -15°C to + 60°C.

The modules shall be rated for a minimum useful life of 48 months. All modules shall meet all parameters of this specification during this period. The individual LEDs shall be wired such that a catastrophic loss or the failure of one or more LED will result in the loss of not more than five percent of the signal module light output.

Unless otherwise specified, the LED signal modules shall have the following electrical characteristics:

TABLE 8.3.2: ELECTRICAL CHARACTERISTICS OF LED SIGNAL MODULES

Characteristics	Module Type		
	Hi -Flux	Dot Matrix	
Operation Voltage	230V (+ 10% , - 6%), 50Hz +1%	230V (+ 10% , - 6%), 50Hz + 1%	
Power Factor	≥ 0.90	≥ 0.90	
Total Harmonic Distortion	≤ 20 %	≤ 20 %	
Power	12W – 15W (Typical : 12W)	8W – 10W (Typical : 10W)	
Intensity	200cd – 800cd	200cd – 800cd	
LED type	AlInGaP, InGaN	5mm (AlInGaP, InGaN)	
LED Mounting Technology	Surface mount	Through holes	
Chromaticity Coordinates (x , y) as on CIE chart	Red	Amber	Green
	0.660 , 0.320 0.680 , 0.320 0.710 , 0.290 0.690 , 0.290	0.536 , 0.444 0.547 , 0.452 0.613 , 0.387 0.593 , 0.387	0.009 , 0.720 0.284 , 0.520 0.209 , 0.400 0.028 , 0.400

8.3.4.3 Construction

The LED signal module shall be a single, self-contained device, not requiring on-site assembly for installation into new or existing traffic signal housing. The power supply for the module shall be integral to the unit.

The assembly and manufacturing process for the LED signal module shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

8.3.4.4 Module Identification

Each module shall have the manufacturer's name, trademark, model number, serial number, date of manufacture (month-year), and lot number as identification permanently marked on the back of the module.

The following operating characteristics shall be permanently marked on the back of the module: rated voltage and rated power in Watts and Volt-Ampere.

If a specific mounting orientation is required, each module shall have prominent and permanent marking(s) for correct indexing and orientation within a signal housing. The markings shall consist of an up arrow, or the word "UP" or "TOP".

8.3.4.5 Target Boards

If specified, target boards shall be provided with each signal face intended for vehicle drivers, extending not less than 275 mm above the centre of the upper optical system nor less than 250 mm below the centre of the lower optical system. It shall extend not less than 280 mm horizontally either side of the vertical centre line of the optical system. Other types of target boards shall be as shown on the Drawings. The target boards shall

be manufactured from a durable resilient material and shall be stiffened where necessary to resist distortion due to wind and extreme ambient temperature. All target boards shall be black with orange border neither less than 45 mm nor more than 55 mm wide.

8.3.4.6 Digital Countdown Unit

Each countdown unit shall consist of an assembly that utilizes LEDs as the light source. The LEDs shall utilize appropriate technology to achieve the required colour and shall be the ultra bright type rated for 100,000 hours of continuous operation from -15°C to + 60°C.

The countdown unit shall be rated for a minimum useful life of 48 months. All modules shall meet all parameters of this specification during this period. The individual LEDs shall be wired such that a catastrophic loss or the failure of one or more LED will result in the loss of not more than five percent of the signal module light output.

The Countdown unit shall consist of a double digit display made of Red and Green LEDs. Timing is derived directly from controller using Vehicle Actuated Data and no timing shall be programmed or otherwise initiated.

Unless otherwise specified, the Countdown Unit shall have the following electrical characteristics:

TABLE 8.3.3: ELECTRICAL CHARACTERISTICS OF COUNTDOWN UNIT

Characteristics	Values		
Operation Voltage	230V (+10%, -6%), 50Hz + 1%		
Power Factor	≥ 0.90		
Total Harmonic Distortion	≤ 20 %		
Power	8W – 10W (Typical : 10W)		
Intensity	200cd – 800cd		
LED type	5 mm (AlInGaP, InGaN)		
LED Mounting Technology	Through holes		
Chromaticity Coordinates (x , y) as on CIE chart	Red	Amber	Green
	0.660 , 0.320 0.680 , 0.320 0.710 , 0.290 0.690 , 0.290	0.536 , 0.444 0.547 , 0.452 0.613 , 0.387 0.593 , 0.387	0.009 , 0.720 0.284 , 0.520 0.209 , 0.400 0.028 , 0.400

The countdown unit on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients.

The Countdown circuitry shall prevent perceptible flicker to the unaided eye over the voltage range specified above.

The countdown unit shall be operationally compatible with currently used controller assemblies (solid state load switches, flashers, and conflict monitors).

Each unit shall have the manufacturer's name, trademark, model number, serial number, date of manufacture (month-year), and lot number as identification permanently marked on the back of the module.

The rated voltage and power shall be permanently marked on the back of the module.

8.4 SIGNAL POSTS / POLES AND MAST ARMS

8.4.1 Standard Requirements

All signal posts /poles, signal mast arms and mountings of signal lanterns / heads shall be as shown in the Drawings. The posts and mast arms shall be so designed and constructed as to provide adequate support and stability for the signal head assembly.

All signal posts shall be of tubular hollow section of steel with a nominal diameter of 100 mm and fitted with a weather-proof cap to prevent ingress of water in compliance with BS EN 40.

Mast arms shall be tubular hollow sections of steel of a generally tapered form mounted on a base plate as shown on the Drawings.

The posts and mast arms shall be capable of having holes drilled in the vertical section, 1m above the ground, for the mounting of one pedestrian push-button assembly in accordance with Sub-Section 8.5. Any other type of post shall get approval from S.O. prior to installation.

8.4.2 Cable Entry

Cable entry hole shall be provided for both planted and flange mounted type posts. For the flanged mounted type posts, the cable entry shall be through the flange plate with a hole of the same diameter as the inner diameter of the post.

8.4.3 Connecting Facilities for Cables

Provision shall be made for the connection of terminating and interconnecting cables coming from within the post or mast arm and of cables from the traffic signal lanterns.

A service door shall be provided to facilitate for inspection and maintenance of the traffic signal system. The details shall be as shown in the drawing.

8.4.4 Location and Erection

The posts and mast arms shall be erected at the approximate locations as shown on the Drawings. On roadways whose edges are defined by a raised kerb, the posts shall be erected so that no part of the signal heads other than overhead signals projects over the roadway.

Where possible, the signal heads should have a clearance of 300mm to 450mm behind the kerb line. However, the post shall be at a distance not less than 1m from the edge line.

In areas where there is no kerb, the posts should be erected so that the signal head is clear of the paved shoulder (or usable area) and should not be less than 2m nor more than 3m from the edge of the nearest traffic lane.

All posts and mast arms shall have their exact location determined by the S.O. and recorded on the as-built Drawings.

8.4.5 Finish

The post shall be free from welding scale, sharp corners and projections, which might cause injury or damage to cable.

After the completion of all manufacturing operations, the post shall be hot-dipped galvanised in accordance with B.S EN 40.

8.4.6 Signal Heads Mounted On Street Lighting Pole

Signal heads shall also be mounted on street lighting pole. Nominal mounting height of signal head shall follow as that of the post-mounted signal head.

Two numbers of service doors shall be provided to facilitate for inspection and maintenance of the traffic signal and street lighting system as shown in the drawing.

8.4.7 Signal Heads Mast Arm and Street Lighting Pole

Signal mast arm shall also be fabricated together with street lighting pole. The poles and mast arm shall be designed and constructed to provide adequate support and stability for the signal head assembly on the mast arm. The poles shall be of hot-dipped galvanised steel.

Two numbers of service doors shall be provided to facilitate for inspection and maintenance of the traffic signal and street lighting system as shown in the drawing.

8.5 PEDESTRIAN PUSH-BUTTONS

8.5.1 Standard Requirements

All pedestrian push-button, their mechanism and operation, shall be in accordance with A.S. 2353 unless otherwise specified herein.

8.5.2 Location

Pedestrian push-button detectors shall be provided facing the footpath at each end of each crosswalk where pedestrian actuated signals are required as shown on the Drawings.

8.5.3 Pedestrian Demand Indicator

When the button is pressed, an internally illuminated panel shall light up bearing a symbolic red standing man. It shall continue to be displayed until the cross signal (green man) commences. The pedestrian demand indicator shall be provided with all pedestrian push-buttons.

8.5.4 Audible Signal

An audible signal shall, be provided with all pedestrian push-buttons in accordance with A.S. 2353, if specified.

8.6 TRAFFIC CONTROLLER

8.6.1 General Requirements

A controller is the complete timing mechanism which controls the signal phases at an intersection. The controller shall be microprocessor-based consisting of a microprocessing unit, interfacing unit for inputs and outputs and ancillary equipment. :

The control equipment and components shall be housed in a weatherproof-cabinet tested to Class IP 55 in accordance with MS IEC 60529.

The controller shall be able to provide eight signal groups of control and shall be capable of expansion to at least sixteen signal groups by the addition of modules on site, which shall be in addition to any special phase required in connection with start up sequences, all reds, etc. It shall also provide a variety of timing functions and differing operational modes. The controller unit shall be capable of operating a minimum of eight plans in a 24hour period.

8.6.2 Housing

The housing shall have a weatherproof enclosure for the protection of power supplies, kWH meter panel, mains supply panel, facility switch, logic module, vehicle detectors , interfacing and lamp switching modules and battery back-up mains supply system (if specified).

The housing cabinet shall be in accordance with A.S. 2578, Part 1, unless otherwise specified herein.

Housing shall be manufactured from aluminium, stainless steel, galvanized steel or mild steel material as specified and approved by the S.O.

For mild steel, the housing shall undergo de-rusting treatment and anti-rust treatment.

All housing except for stainless steel shall be coated with epoxy dry-powder and oven baked semi-gloss enamel grey.

If a stainless steel housing is specified, all material shall be totally made of stainless steel. All components shall be fabricated using stainless steel sheet not thinner than 14SWG. No additional anti corrosion and paint treatment are required unless otherwise specified.

The housing shall be bolted to steel channel base on concrete plinth.

Appropriate means of entry and support for cables shall be provided.

Sufficient ventilation shall be provided to prevent condensation inside the cabinet under all weather conditions. Charcoal or some other dehydration agent shall be placed in the housing as directed by the S.O.

All non-current carrying metal parts shall be bonded together and effectively earthed in accordance with MS IEC 60364.

All means of access shall be protected by locks of different patterns and the corresponding locks and keys shall be identical for controller housings of the same make, type and series. Not less than two keys of each type shall be supplied with each controller and they shall be handed over to the S.O. after the completion of testing and commissioning. For additional security, metal bracket bar with pad lock shall be installed

to hold the controller housing. A log book shall be provided and attached to the housing.

8.6.3 Controller Mains Supply Panel

The controller mains supply panel shall include one number of single pole miniature circuit breaker (MCB) of minimum rated current 30A with a breaking capacity not less than 10kA (rms) complying with MS IEC 60898 and of B-type with Class 3 energy limiting characteristics.

Tinned copper earthing bar of cross sectional area not less than 25mm x 6mm shall be installed.

The surge protective devices (SPDs) modes of protection shall be each phase-to-neutral, each phase-to-earth and neutral-to-earth for either single phase or three phase supply systems. The impulse current (I_{imp}), nominal discharge current (I_n), maximum discharge current (I_{max}) and open-circuit voltage (U_{oc}) rating per mode of protection of SPD and the respective voltage protection level (U_p) shall be as indicated in Table 4.

All these requirements shall be comply with unless otherwise specified in the drawings.

TABLE 8.6.1: CLASSIFICATION OF SPDS

Location of Controller Mains Supply Panel	Panel Receiving Energy from the Power Supply Authority	
Impulse Test Classification (MS IEC 61643-1)	Class I	Class II
Impulse Current, I_{imp} (10/350 µs) per mode	≥ 12.5 kA	
Nominal Discharge Current, I_n (8/20 µs) per mode		≥ 20 kA
Maximum Discharge Current, I_{max} (8/20 µs) per mode		≥ 65 kA
Voltage Protection Level, U_p (L-N, L-E, N-E) at I_{imp} or I_n or U_{oc}	≤ 1500 V	≤ 1500 V

The controller shall be suitable for operation on 230V (+10%, -6%) 50Hz (± 1%) supply systems.

8.6.4 Facility Switch

A facility switch shall be provided to switch the signal lanterns to ON, OFF or FLASH or other facilities such as manual operation. The switch shall only control the signal lamps and flashing amber circuits while leaving the control equipment fully operative.

Access to this facility shall be via a separate locked door or some other means which does not give access to the controller. The facility shall be located not less than 1m from the ground level.

8.6.5 Pedestrian Facilities

Pedestrian indications shall be allocated as exclusive phases or be connected in parallel to a green phase(s).

When the pedestrian indications are connected in parallel to a green vehicle phase, the steady pedestrian green shall commence at a preset period adjustable to 0, 1, 2, 3, 4 or 5 seconds before or after the start of the green vehicle phase. The steady pedestrian green shall persist until the end of a preset period.

It shall be followed by the flashing pedestrian green or digital countdown unit. For flashing pedestrian green, the frequency of blinking shall be at 76 to 84 flashes per minute, and the lamp shall be on for 50% to 70% of the time. The amber signal terminating the vehicle green phase shall not commence until a preset period adjustable to 0, 1, 2, 3, 4 or 5 seconds has elapsed after the termination of the flashing pedestrian green.

When the pedestrian indications are allowed an exclusive phase, the pedestrian steady green shall be controlled by the appropriate control command and followed by the flashing green pedestrian signal. The inter-green periods shall be inserted before the pedestrian steady green and between the end of the flashing green or countdown unit and the start of the next vehicle phase green. It shall be possible to operate the pedestrian phase with or without pedestrian detection. This shall be selected by a switch or other methods within the controller, subject to the approval of the S.O.

8.6.6 Logic Module

The microprocessor based logic module shall consist of the following minimum requirements:-

8.6.6.1 Microprocessor System

The Microprocessor system shall contain a stored program in read-only-memory (ROM). Part or all of the ROM shall be reprogrammable. The stored program shall permit the traffic controller to be operated in different traffic modes as follows:-

a. Urban traffic control operation (UTC)
b. Isolated traffic-actuated operation;
c. Cables or wireless for synchronous operation;
d. Fixed time operation.

All information relating to a particular signal installation, such as number of plans, signal groups, detector logic, time setting and description of logical and conditional features, shall be contained in the reprogrammable ROM.

Time settings may be stored by means of either:-

a. electrically erasable ROM (EEROM)
b. reprogrammable ROM (EPROM)
c. battery back-up RAM

The time settings shall be such that they may be changed by means of a portable programming unit while the controller is functioning. The reprogrammable ROM shall be separate from the CPU and its associated circuitry to facilitate field servicing.

8.6.6.2 Input/Output Interfaces

The Contractor shall provide for the approval of the S.O., detailed technical information on the input and output interfaces. Inputs include those from vehicle detectors, pedestrian push buttons and signal links. The output shall be connected to the vehicle signal light, pedestrian light, wait indicators and signal linking.

8.6.6.3 Real Time-of-Day Clock

For wireless synchronous operations, a hardware clock shall be provided. The circuit generating the hardware clock shall be backed up by a standby battery for up to 48 hours or more (when fully charged).

The clock shall derive its timing from two sources, either from a crystal oscillator or Global Positioning System (GPS) Time Synchronization Module if specified. The real time clock shall provide time in seconds, minutes, hours and days to the microprocessor via a data bus.

8.6.6.4 Operator Interface and Controller Display

A portable programming unit shall be provided as an operator interface with the controller logic module, if specified. Visual indicators shall be provided to indicate the status of various traffic parameters such as the phase currently running, base phase step for each phase, demand for each phase, pedestrian demands recorded, etc.

When operated in link mode, the display shall be able to provide all traffic parameters associated with the appropriate link mode.

8.6.6.5 Power Supply Monitoring System

All D.C. power supplies to various cards in the logic module shall be constantly monitored to ensure correct operation of the controller.

The monitoring shall be designed so that if one or more of the supply output voltages falls below certain preset levels, the power failure detection circuit will activate to cause the controller to shut down the traffic signal system.

The mains supply voltage shall also be monitored. Any voltage drop below certain levels shall cause a black out situation.

A watchdog timer shall be used to detect failure of the microprocessor system to execute its traffic control program. Any failure to execute traffic instruction shall black-out the intersection signalization and switch over to flashing amber signal.

8.6.7 Battery Back-up System For Traffic Signals utilizing Light Emitting Diodes (LED) Traffic Signal Modules.

8.6.7.1 General

The battery back-up system (BBS) shall include, but not be limited to the following:

inverter/charger, power transfer relay, batteries, a separate manually operated non-electronic by-pass switch and all necessary hardware and interconnect wiring.

The BBS shall provide reliable emergency power to a traffic signal in the event of a power failure or interruption. The BBS shall be capable of providing power for full

run-time operation for an "LED-only" intersection (all colours red, amber and green) or flashing mode operation for an intersection using red LEDs. The BBS shall be designed for outdoor applications.

8.6.7.2 Operation

The BBS shall provide a minimum two (2) hours of full run-time operation for an "LED-only" intersection (minimum 700W/1000VA active output capacity with 80% minimum inverter efficiency).

The maximum transfer time from loss of utility power to switchover to battery backed inverter power shall be 150ms.

Operating temperature for both the inverter/power transfer relay and manual by-pass switch shall be 0°C to +74 °C.

Both the power transfer relay and manual by-pass switch shall be rated at $230V_{AC}$ (+10%, -6%) /30A.

The BBS shall use a temperature-compensated battery charging system. The charging system shall compensate over a range of 2.5 – 4.0mV/°C per cell.

Batteries shall not be recharged when battery temperature exceeds 50°C $\pm$3°C.

BBS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the local power utility service.

In the event of inverter/charger failure, battery failure or complete battery discharge, the power transfer relay shall revert to the normally closed state, where utility line power is reconnected to the cabinet.

Recharge time for the battery, from "protective low-cutoff" to 80% or more of full battery charge capacity, shall not exceed twenty (20) hours.

8.6.8 Mains Supply Interruptions

In the event of a mains supply interruption $\leq$ 50ms, the controller shall continue to function correctly. When a controller commences to fail (after a mains supply interruption in excess of 50 milliseconds) it shall shut down for the duration of the mains interruption plus a nominal period of about 5 to 10s. At the expiration of this nominal period the controller shall commence operation at an All Red state. This state shall persist for at least 5s and shall be followed by the pre-selected phase.

8.6.9 Inputs

All inputs shall be suitably protected against high voltage peaks and short circuits.

8.6.10 Interchangeability

All parts shall be interchangeable with like parts for equipment of the same make, type and series.

8.6.11 Vibration and Noise

The apparatus shall be reasonably quiet and the mechanism shall not cause undue vibration. The apparatus shall be constructed so as to reduce to a minimum any damage to lamps and equipment due to vibration caused by traffic.

8.6.12 Radio Interference

The design of equipment shall be such as to prevent interference to telegraphic, telephonic or radio transmissions. The apparatus will be considered to meet this requirement, as far as radio interference is concerned, if the interference produced by it does not exceed the limits laid down in relevant parts of MS IEC 61000.

8.6.13 Safety

Where right of way signals are shown for any controlled traffic in one phase, it shall not be possible through failure of any operating component of the controller to give a right of way signal to a conflicting traffic signal.

The Contractor shall satisfy the S.O. as to how the conflicting green state (Green Conflict) can be detected and what action is to be taken on its detection. The use of two independent safeguard systems is favoured. A method of testing the operation of the safeguards shall be provided.

8.6.14 Timing

The duration of all periods timed by the controller shall be within $\pm$ 10% of the nominal time when the applied main voltage is within the range between $\pm$ 10% of the nominal value and $\pm$ 4% of its nominal frequency. This shall apply to those timing arrangements which measure selected fixed periods. The flashing rate of any flashing signals shall be between 76 and 84 flashes per minute within the same voltage and frequency limits.

8.6.15 Sequence of phasing

Unless otherwise specified, the sequence of phasing for signal used junction shall be in anti-clock wise direction.

8.7 VEHICLE DETECTORS

8.7.1 Standard Requirements

All equipment, its construction and performance, shall be in accordance with A.S. 2703 unless otherwise specified herein.

8.7.2 Number of Traffic Lanes

The loop detector shall sense traffic flow on one to four traffic lanes depending on where it is installed. It shall sense traffic moving in one direction only and detection on a two way road shall be achieved by using two sets of detectors so that the information obtained for each direction is separate.

Unless otherwise specified, a traffic counting loop shall be installed on each lane.

8.7.3 Performance Requirements

The detector shall respond to any vehicle, normally encountered on public roads traveling at any speed. The Contractor shall satisfy the S.O. with respect to the accuracy of the detector unit in terms of false or nil presence actuation at normal operating sensitivity for all types of vehicles including high-bodied vehicles and multi-axle vehicles.

Other type of vehicle detector shall get approval from the S.O. prior to installation.

8.8 ROAD WORKS

8.8.1 General

The Contractor shall carry out all necessary road works in connection with the installation of the traffic signal system. These shall include any road works associated with:-

a. installation of traffic signal controller;
b. installation of signal posts/poles and heads;
c. installation of cable ducting and heavy duty pre-cast concrete pits;
d. cutting of slots for detector loops and backfilling of slots;
e. construction of cast in-situ pits when necessary.

If an existing duct has been installed across the road carriageway, all new cross-carriageway cabling shall be carried in this duct when possible.

8.8.2 Permission to Excavate Road

The Contractor shall apply for permission from the S.O. to excavate the roadway. The application shall be made not less than seven (7) working days before the commencement of the work.

The Contractor shall comply with the following conditions and other additional instructions from the S.O. -

a. trenching in side-tables, footpaths and carriageways shall be excavated, backfilled, reinstated and maintained as specified in this Sub-Section;
b. cable ducts to be laid in:
    i. new carriageway shall be at least 750mm below the carriageway level;
    ii. existing carriageway shall be at least 450mm below the carriageway level;
c. cables running longitudinally in footpaths and side-tables shall be at least 600mm clear of the edge of the kerb line or carriageway and at least 75mm below the adjacent carriageway channel level;
d. no work shall be done during traffic peak hours unless approved by the S.O.

8.8.3 Excavation, Backfilling, Reinstatement and Maintenance of Excavations

8.8.3.1 General

The Contractor shall cause as little obstruction as possible to the general public during the execution of all works under this Contract, and shall pay due regard to the interests and convenience of the public and of all private persons who have property in or are resident in the neighborhood of the works.

The Contractor shall ensure that no delay occurs between opening excavations, laying of cables, backfilling and reinstatement and that these actions form a continuous process.

8.8.3.2 Excavation

Each trench shall be excavated to the required level and materials taken out shall not be re-used unless otherwise specified or directed by the S.O.

For excavation in side-tables, turfs shall be carefully removed, stacked and periodically watered for later re-use. The remaining excavated materials may be stockpiled on the site

for later backfilling but excavated topsoil shall be kept separate for landscape use where necessary.

All materials from excavation works are not allowed to be reused as backfilling material and should be removed from the work site immediately after the excavation. No materials are allowed to be stockpiled beside the carriageway.

All sides of excavations shall be vertical. All hard surfaces including flexible pavement shall be cut using appropriate machinery such as diamond cutter. In soft or unstable ground the sides shall be adequately supported.

All excavations shall be kept free of standing water.

If, for unavoidable reasons, a trench running laterally across a road cannot be backfilled and must be left open overnight or for a longer period, then steel plates, securely placed and adequate to take traffic loading, shall be placed across the trench and the section of road opened to traffic.

8.8.3.3 Bedding of Excavation

Before ducts are laid, the trench beds shall be leveled and sand placed on the bed and hand tampered to a thickness of not less than 75mm. All ducts shall be covered by a layer of sand hand tampered to a thickness of at least 75mm above the crown of the duct.

8.8.3.4 Cable Ducts

Cable duct shall be as specified in Appendix 8A (L-S3: Specification For Low Voltage Underground Cable, Cawangan Kejuruteraan Elektrik, JKR) except that for the depth of duct shall be at least

a. 450mm below existing carriageway level; or
b. 750mm below new carriageway level.

8.8.3.5 Cable Laying and Installation

All cables either laid direct in the ground or installed in precast concrete trenches shall be handled, laid and installed as specified in Appendix 8A (L-S3 : Specification For Low Voltage Underground Cable, Cawangan Kejuruteraan Elektrik JKR).

8.8.3.6 Backfilling of Excavations and Reinstatements

For excavations in sidetables, berms and slopes, the excavated material shall be replaced in 150mm layers in the reverse order to which the material was excavated. Each layer shall be compacted with a power driven rammer. The top 150mm of the excavation and adjacent disturbed ground shall be filled with good loamy topsoil and hand tampered. Approved quality grass turfs shall be closely and continuously fitted over the top soiled area where necessary and directly pegged down to prevent displacement.

For excavations in existing carriageways and footpaths the backfilling shall be done using clean sand and approved granular aggregate for the first 150mm depth. The layer shall be compacted using a power driven rammer. A tack coat of cationic bituminous emulsion shall be applied on the granular aggregate surface and a final layer of 300mm thick layer of asphaltic premix shall be laid and compacted in two 150mm layers, all in accordance with the relevant requirements of Section 4 – Flexible Pavement of this Specification.

8.8.3.7 Sensing Loop Slots

The Contractor shall be responsible for providing the slot in the roadway for the loop sensor; the installation and jointing of the loop feeder cable; the backfilling of the slot in the roadway; and the slot or trenches for the feeder cables, all as shown on the Drawings.

The width of the slot in the roadway required to accommodate the detector sensing loop shall not exceed 12mm and the depth of the slot shall be such that no part of the loop or feeder, after reinstatement, shall have a cover of not less than 25mm.

Notwithstanding to the requirement for the contractor to obtain approval from the S.O. with respect to details of the loop configuration, the contractor shall also comply with the following slot filling procedures:

a. No water should be standing in the slot before laying loop cable.
b. Transfer pre-mixed sealant to a watering can and gently pour into the slot.
c. Wipe or scrape excess sealant off the road surface only while still liquid form.
d. Broken gutter areas where lead-in wires entering footpath shall be repaired by using a sand/cement mix or the same sealant used for the loop installation.

8.8.3.8 Maintenance of Drains and Services During Excavations

The Contractor shall ensure that he has full knowledge of the location of all drains and services in the area of any excavation prior to the excavation commencing. The Contractor shall ensure that all precautions are taken not to disturb such drains and services and shall be responsible for their maintenance during the reinstatement of such excavations.

The Contractor should note if the Site of the Works is subject to frequent and heavy rainfall and all precautions shall be taken to maintain existing waterways to prevent flooding.

8.8.3.9 Reinstatement of Drains and Precast Units

The Contractor shall carry out the reinstatement of all existing precast channel drains, gullies, pavement slabs, dividers, kerbs, etc., which have been affected by any trench opening. Only excavated units in a sound and undamaged condition may be reinstalled, otherwise the Contractor shall supply and lay similar new units. The units shall be replaced to the original lines and levels and shall be bedded, backed and jointed to the satisfaction of the S.O.

8.8.3.10 Completion of Works

On completion of reinstatement works at any one site, the Contractor shall clear away all debris, surplus materials and plant and leave the site in a clean and tidy condition. The Contractor shall carry out any further remedial works as directed by the S.O. and shall obtain the S.O's written approval for the reinstatement works.

8.8.3.11 Maintenance of Excavation

The Contractor shall be entirely responsible for the proper maintenance and good condition of each excavation and each reinstatement up to a period of three (3) calendar months after the date of the S.O.'s written approval of such reinstatement works.

All excavation sites prior to, during, and after reinstatement shall be maintained in a sound and firm condition, free from depressions, humps, loose stones and any other similar defects such as not to constitute danger or unreasonable nuisance to traffic or

members of the public. Loose materials or stones shall not be allowed to accumulate over or around any excavation, but shall be promptly swept clear.

Any part of reinstatement in a footpath or carriageway that settles more than 15mm below the adjacent undisturbed surface level shall promptly be re-surfaced to a level not more than 15mm above the adjacent undisturbed surface level. The resurfacing shall be carried out by applying a prime/tack coat and asphaltic premix as specified in Section 4 of this Specification.

The Contractor shall be required to maintain a small mobile gang of workmen for the above purpose, and a regular system of daily inspection shall be instituted for all trenches awaiting temporary and permanent reinstatement. Should the Contractor default in the maintenance of excavations and reinstatement where, in the S.O.'s judgement, such default would constitute in any way a traffic hazard, then the S.O. shall have the power to attend forthwith to such defects and the entire cost of the work plus 25% shall be borne by the Contractor.

Before the expiration of the maintenance period of each item of work, the Contractor shall write to the S.O. for final inspection of the work to determine any outstanding defects which have to be rectified. The Contractor will only be absolved of all the responsibilities of the maintenance after such defects are rectified to the satisfaction of the S.O.

In the event that the Contractor fails to notify the S.O. of the date of expiration of the maintenance period and has not arranged for the inspection of the work, the maintenance period of each item of work shall be deemed to have been extended by the Contractor due to his fault to such time until the final inspection is carried out.

8.8.4 Traffic Arrangements

8.8.4.1 General

Obstructions and excavations shall be adequately fenced and guarded at all times for the protection of all persons who use the roadway. Particular attention shall be paid to the positioning of the barriers. The whole obstruction or excavation shall be completely fenced off, but unnecessary blocking of traffic lanes shall not be permitted. Roads shall not be used for the unnecessary storage of materials.

On multilane roads, not more than one traffic lane in either direction shall be closed except as may be otherwise directed by the S.O. On roads of not more than one traffic lane in each direction, the Contractor shall ensure that both lanes are kept open during peak periods as previously defined. This may be accomplished by the use of steel plates as specified in Sub-Section 8.8.3.2.

When the work is such that the simultaneous closing of several lanes cannot be avoided and would cause undue interference with traffic, the work should either be carried out at night or during weekends. However, the S.O. may give permission for the simultaneous closing of lanes for emergency works or other works as deemed necessary.

8.8.4.2 Arrangement and Location of Signs, Barriers and Barricades

The general arrangement and location of temporary signs at works in progress shall be strictly in accordance with ARAHAN TEKNIK (JALAN) 2C/85, published by Cawangan Jalan, Ibu Pejabat JKR, Kuala Lumpur, and shall be submitted by the Contractor and approved by the S.O. before work commences.

Work on a road involving less than one-third of a traffic lane and work on a footpath in the immediate vicinity of the carriageway of a high speed road shall be deemed to be minor obstructions. In these cases, as it will not be necessary to close up one full lane, appropriate length of barriers shall be used in accordance to ARAHAN TEKNIK (JALAN) 2C/85 or any latest version of the guideline thereafter.

All traffic signs used in temporary signing must be reflectorised. When practicable, signs shall be sited where they will be clearly visible at all times.

8.8.4.3 Temporary Flashing Warning Lamps

Temporary flashing warning lamps or beacons shall be used during the hours of darkness in conjunction with all temporary signs, barriers and other traffic control devices which are to remain in position at night. Lamps shall be kept alight at all times during the hours of darkness and shall be placed at salient points of the site every night.

8.8.4.4 Use of Traffic Guidance Cones

When a portion of a roadway is closed to traffic by the use of barriers, barricades or signs, traffic guidance cones shall be placed on the road so as to guide traffic smoothly from the wide section to the narrow section in which a portion of the roadway has been closed to traffic.

Cones shall be used only when the work is in progress or where there is a watchman who can reposition any of the cones which may have been dislodged by the traffic. Otherwise they shall be removed from the roadway when work ceases at night. At night, continuously operating temporary flashing warning lamps or beacons shall be used to guide the traffic.

Cones shall be of rubber or equivalent flexible material and shall be bright orange.

8.8.4.5 Temporary Traffic Diversions

For the duration of the work, a satisfactory roadway shall be provided for the traffic. Where a sufficient width of carriageway is not available, a temporary traffic diversion shall be constructed if possible. The extra carriageway shall be properly maintained at all times for the duration of the work.

The maintenance of pedestrian movement shall be provided by construction of temporary walks, barricades and handrails. Certain areas along the construction site may be restricted to pedestrian use where such restrictions are in the interest of pedestrian safety.

8.8.4.6 Temporary Traffic Control

It is essential that traffic control at the site be exercised diligently and by competent personnel, if the need arises.

The methods of temporary traffic control are:-

a. Police supervision: this applies where the works are of a very short duration with some special feature, such as a busy road junction;
b. Manually operated 'Stop' and 'Go' signs: this applies at works of short duration, provided that traffic is not dense. Red and green flags should, under no circumstances, be used for traffic control, but could be used to supplement the disc signs.

8.8.4.7 Plant and Equipment

In all cases where traffic is permitted to use the whole or a portion of the existing road, all plant items and similar obstructions shall be removed from the road at night, if at all practicable. During the day, a red flag shall project beyond the extremity of all plant items (other than vehicles) adjacent to the traffic lane.

Plant and equipment shall be lit at night if within 5m of the edge of the carriageway by two red lights suspended vertically from the point of obstruction nearest to the carriageway. The lights may be omitted in cases where there are permanent obstructions, such as trees less than 5m from the edge of carriageway and the plant or equipment are not closer to the road than the permanent obstructions.

8.8.4.8 Vehicles

Vehicles which carry out operations on the road and which are required to travel slowly or to stop at frequent intervals should be made as noticeable as possible. This shall be achieved by painting such vehicles with a distinctive colour, and painting their rear portions with diagonal stripes of contrasting colours, and providing flashing lights on the top of the vehicles. They should also have a plate on the rear side with the words `SLOW MOVING' or `KENDERAAN PERLAHAN'.

8.8.4.9 Maintenance of Signs, Lamps, Barriers, Temporary Traffic Diversions, etc.

Signs, lamps, barriers and other traffic control devices shall be maintained in good order and in the correct position day and night. Signs shall be neat, clear and legible at all times. Temporary traffic diversions shall be maintained in good order at all times.