ข้อกำหนดและมาตรฐานทั่วไป

งานติดตั้งไฟสัญญาณจราจรและไฟกระพริบบนทางหลวง

GENERAL SPECIFICATION

FOR ROAD TRAFFIC SIGNALS AND FLASHING TRAFFIC SIGNALS

กรมทางหลวง กระทรวงคมนาคม

มกราคม 2523

คำสั่งกรมทางหลวง
ที่ บ.1/62/2521
เรื่อง แต่งตั้งคณะกรรมการกำหนดมาตรฐานเรื่องไฟฟ้าแสงสว่างและไฟสัญญาณจราจร

ตามคำสั่งกรมทางหลวงที่ บ.1/61/2521 ลงวันที่ 9 พฤศจิกายน 2521 เรื่อง แต่งตั้งคณะกรรมการกำหนดมาตรฐานเรื่องไฟฟ้าแสงสว่างและไฟสัญญาณจราจร นั้น เพื่อประโยชน์แก่ราชการ จึงให้นายรักษ์ สตายุ ตำแหน่งนายช่างโยธา 5 กองบำรุง เป็นกรรมการร่วมในคณะกรรมการดังกล่าวด้วย

สั่ง ณ วันที่ 27 พฤศจิกายน 2521

(นายเฉลียว วัชรพุกก์)
อธิบดี

คำสั่งกรมทางหลวง
ที่ บ.1/61/2521
เรื่อง แต่งตั้งคณะกรรมการกำหนดมาตรฐาน เรื่องไฟฟ้าแสงสว่างและไฟสัญญาณจราจร

เพื่อประโยชน์แก่ราชการ จึงให้แต่งตั้งคณะกรรมการกำหนดมาตรฐาน เรื่องไฟฟ้าแสงสว่างและไฟสัญญาณจราจร ซึ่งประกอบด้วยข้าราชการ ดังมีรายนามต่อไปนี้

1. ผู้อำนวยการกองสำรวจและออกแบบ	เป็นประธานกรรมการ
2. นายเอนก ปิยางค์สุวรรณ ตำแหน่งนายช่างโยธา 6	เป็นกรรมการ
3. นายปริญญา สูตะบุตร ตำแหน่งนายช่างโยธา 6	เป็นกรรมการ
4. นายปัญญา วัฒนสินธุ์ ตำแหน่งวิศวกรโยธา 5	เป็นกรรมการ
5. นายวงศ์ชัย เจริญสวรรค์ ตำแหน่งวิศวกรโยธา 5	เป็นกรรมการ

ทั้งนี้ตั้งแต่บัดนี้เป็นต้นไป

สั่ง ณ วันที่ 9 พฤศจิกายน 2521

(นายเฉลียว วัชรพุกก์)
อธิบดี

บันทึกข้อความ

ส่วนราชการ กองสำรวจและออกแบบ

ที่ ดด.0610/577 วันที่ 17 กันยายน 2521

เรื่อง การกำหนดมาตรฐานไฟสัญญาณจราจร

เรียน จทล. ผ่าน รทว.

ตามคำสั่งกรมฯ ลงวันที่ 8 พฤศจิกายน 2521 แต่งตั้งคณะกรรมการกำหนดมาตรฐานเรื่องไฟฟ้าแสงสว่างและไฟสัญญาณจราจร รวม 5 นาย และตามคำสั่งกรมฯ ลงวันที่ 27 พฤศจิกายน 2521 แต่งตั้งคณะกรรมการดังกล่าวเพิ่มอีก 1 นาย รวมเป็นคณะกรรมการทั้งสิ้น 6 นาย คณะกรรมการดังกล่าวได้นัดประชุมดำเนินการตามคำสั่งกรมฯ เรื่องไฟฟ้าแสงสว่าง เสร็จเรียบร้อยและเสนอกรมฯ ไปแล้วเมื่อวันที่ 15 มกราคม 2522 นั้น

บัดนี้ คณะกรรมการได้พิจารณาเรื่องการกำหนดมาตรฐานของไฟสัญญาณจราจรเสร็จเรียบร้อยแล้ว เฉพาะภาษาอังกฤษ ซึ่งเดิมได้ใช้ภาษาอังกฤษอยู่แล้ว ต่อไปจะได้ทำการแปลเป็นภาษาไทยส่งตามมาภายหลัง พร้อมนี้ได้แนบมาตรฐานของไฟสัญญาณจำนวน 2 ชุด ซึ่งคณะกรรมการได้กำหนดไว้เสร็จแล้วเสนอมา เพื่อกรมฯ ได้โปรดพิจารณาสั่งการต่อไปด้วย

ลงนาม นายอารมย์ จุฬจัมบก ประธานกรรมการ
(นายอารมย์ จุฬจัมบก)

ลงนาม นายเอนก ปิยางค์สุวรรณ กรรมการ
(นายเอนก ปิยางค์สุวรรณ)

ลงนาม นายปริญญา สูตะบุตร กรรมการ
(นายปริญญา สูตะบุตร)

ลงนาม นายบัญชา วัฒนสินธุ์ กรรมการ
(นายบัญชา วัฒนสินธุ์)

ลงนาม นายวงศ์ชัย เจริญสารรค์ กรรมการ
(นายวงศ์ชัย เจริญสารรค์)

ลงนาม นายรักษ์ ศตายุ กรรมการ
(นายรักษ์ ศตายุ)

GENERAL SPECIFICATION

FOR ROAD TRAFFIC SIGNALS AND FLASHING

1. General

1.1 Description

This work shall consist of the supply of all signal heads, supports, controllers of control units, cables, switchgear with all necessary ancillary equipment together with the transportation, storage, erection, connection and testing of the same in order to supply a complete traffic signal or flashing traffic signal installation in accordance with the Drawings and as specified herein and in the Special Provisions. Design of the system may be included.

1.2 Patents

The Contracter shall hold and save the Government of Thailand, its officers, agents, servants and employees harmless from liability of any nature of Kind including costs and expenses for or on account of any patented of unpatented invention articles devices or appliances manufactured or used in the performance of this contract including their use or disposal by the Government.

1.3 Responsibility for Design and Materials

Items of equipment and parts shall have maker's specifications agreeing with those of the U.S.A. Standards Institute, the American Society for Testing Materials, the American Association of State Highway Officials, the National Bureau of Standards, the British Standards Institution or other similar internationally recognised body. All work shall be done and all goods shall be made in strict accordance with the requirements of the Electrical Code of the Kingdom of Thailand and of the regulations of the Electricity Supply Authority concerned.

The Contractor shall be solely responsible for the adequate design and the co-ordinated functioning of all goods and constructions furnished

available as stock from this agent. In the case of spares which will not be stocked locally, he shall state their source of supply and delivery time to Bangkok.

After completion of the work, the Contractor shall carry out all repairs needed and replace all faulty parts and materials for the duration of the Maintenance Period without extra charge.

The Contractor shall undertake the servicing and repair operations as specified on the Drawing or in the Special Provisions.

1.6 Mains and Services

Prior to commencement of any work, the Contractor shall obtain all relevant information from the appropriate authorities concerning the location of any public or private tunnel, drain, conduit, main or cable which may be affected by the works to be carried out under this contract.

The Contractor shall be responsible for any damage caused to any such mains or services by the works carried out under this contract or services. The Contractor shall make his own arrangement with the appropriate authorities for any repairs to or moving of such mains or services and this work shall be done without extra charge either for works done or for delay which may be caused.

1.7 Electricity Supply

The Contractor shall carry out negotiations with the Electricity Supply Authority concerned for an electricity supply to the installation, and any casts associated with obtaining this supply shall be included in the Contract rates. The Contractor must ensure that the equipment supplied will function correctly at the supply voltage, and must allow for normal variations and surges.

1.8 Definitions

Unless specifically defined herein, definitions shall be as given

in British Standard 892 : 1967 "Glossary of Highway Engineering Terms" and in British Standard 505 : 1971, "Specification For Road Traffic Signals", both as amended at the time of the bid.

2. Materials and Equipment

2.1 Signal Face

Each signal face, unless flashing traffic signal is specified, shall consist of three optical systems arranged vertically. The top optical system shall show red, the center amber, and the lowest green. Where green arrows are used they may either replace the green light or be additional to such light in one of the permitted arrangements shown in Fig. 1.

For flashing traffic signal, each signal face shall consist of one optical system, which shall be fitted with either amber or red glass as specified on the Drawing or in the Special Provision.

Visors shall be supplied if required to give the most efficient operations under all conditions.

Unless otherwise specified a backing board shall be provided with each signal face, extending not less than 230 mm. from center lines of all optical systems. Backing boards are not required with portable or flashing traffic signals.

2.2 Optical Systems

Optical systems shall consist of a lens, a reflector, a lampholder and a clear traffic signal lamp visible to the traffic to be controlled. they shall be housed in a non-ferrous corrosion resistant casing which shall be weather tight and capable of being securely fixed in direction and elevation. Access shall be provided by hinged doors which when shut shall be forced against a neoprene gasket or other materials approved by the Engineer on the body and fastened by a simple, corrosion resistant, non-

detachable fastening device which does not required special tools for operation. The Anti-Phantom effect shall be incorporated in the design of the optical system such that the reflected light beam falling on the signal face in any direction shall be kept minimal

2.3 Lenses

Lenses shall be made from best quality glass or other materials approved by the Engineer, free from imperfections, and shall conform to the latest requirements of the relevant ASA or British Standards for colour and transmittance. Unless otherwise specified, all lenses will be unlettered and shall be mounted so as to display a circular area not less than 200 mm nor more than 215 mm in diameter towards the traffic to be controlled. The lens shall be so designed and finished that when it is installed in an optical system as herein described, that system shall, when the lamp is illuminated, display a uniformly bright area to traffic without any shadows or dark areas. The polar curve shall be reasonably smooth and free from sudden changes or secondary maxima. The mounting of the lens shall ensure that there will be no escape of light from the lamp, apart from that passing through the lens itself.

Where green arrows are used they shall have an optical system having a diameter of not less than 295 mm nor more than 305 mm. Each arrow lens shall show only one arrow direction. The arrow shall be the only illuminated part of the lens.

2.4 Reflectors

Reflectors may be of silvered glass or metal. Silvered glass reflectors shall conform to Clause 8.02 of the Institute of Traffic Engineers Technical Report No. 1 "Adjustable Face Vehicle Traffic Control Signal Head Standard" as approved by the American Standards Institute or Clause 3.4.1 of British Standard 505:1971. Metal reflectors shall be of non-ferrous metal not less than 0.55 mm. thick plated with nickel and

than chromium plated, or other suitable construction which is not less effective. Metal reflectors shall be stiffened and supported to prevent distortion.

2.5 Lampholders

Each lampholder shall be suitable for the type of lamp used, and the dielectric shall be of a tough incombustible insulating material which will not be affected by prolonged heating to 200° C nor by prolonged immersion in water. The lampholder shall be permanently positioned in such a way that the lamp filament shall be at the focal centre of the reflector. The metal parts of the lampholder shall be electrochemically compatible with other contiguous metals.

2.6 Lamps

The lamps shall be low voltage long life tungsten halogen lamps, or such other type as approved by the Engineer, having an out-put of 900 lumens minimum. Each lamp shall be provided with an appropriate transformer mounted within the signal head.

2.7 Wiring

All lampholders shall be wired to a suitable terminal block in the housing. Wires shall be of a type approved by and agree with the Electricity Supply Authority, and free of all joints except in terminal blocks and shall be permanently colour coded to facilitate maintenance and repair. At each signal location unless shown otherwise on the Drawings there shall be a terminal compartment provided on the mounting which shall be provided with a terminal block containing screw type terminals of suitable size. A weathertight cover shall be provided to the terminal compartment which will give ready access to the terminal block, and the terminal compartment and cover shall be of sufficient strength to remain intact if the mounting pole is knocked down. Connections from the signal

face to the terminal compartment, where external, shall be protected by approved metallic tubing. Buried cables from the controller to signals and detectors shall be suitably armoured or laid in approved conduit and free of all joints except at terminal blocks or junction boxes. Wiring to signals will not be run to a terminal block on a signal post unless it is to be connected to a signal that is mounted thereon. Sufficient conductors shall be provided to perform the functional operation of the signal system throughout and in addition between the controller and the signals three spare conductors shall be provided of size equal to the largest conductor in the run except neutral. Wires subject to bending due to opening and closing of doors shall be stranded. All metallic parts not carrying current shall form an electrically continuous system which shall be earthed, or they shall be separately earthed, using bare copper conductors (or other type approved by the Electricity Supply Authority) with a minimum cross-sectional area of 4 square millimeters but not less than the requirement of the Electricity Supply Authority. All items below ground level shall be so designed and installed that they will continue to operate without fault if immersed in ground water.

2.8 Posts

Posts shall consist of solid drawn or longitudinally butt welded mild steel tube having a diamater of not less than 100 mm. and wall thickness of not than 4.5 mm.

It shall be so designed and constructed as to provide adequate support and stability for the signal head and shall be fitted with a weather-proof cap. A suitable base plate and finial shall be provided for each post.

Unless otherwise specified the post shall be of sufficient length to allow at least 0.6 m. below ground level when correctly erected.

The post shall be provided with cable slots near the base and with the required cable bush holes in correct position. All cable slots and

holes shall be free of burrs and rough edges. Suitable means shall be provided to fasten base plates, brackets and signal heads firmly to posts and to allow adjustment where required. All nuts, bolts, fastening hinges and adjusting brackets on posts, finial, terminal compartment and signal heads shall be cadmium plated or of stainless steel or made corrosion resistant in a not less effective manner.

2.9 Painting

Paint and painting shall be in accordance with Section 5.12 of these specifications* with the following additions and modifications. Posts and brackets shall be provided with a prime coat and two coats of undercoat before delivery and sufficient finishing coat shall be provided for final painting after erection. The signal heads, terminal compartments, visors, louvres, and sighting screens shall be delivered primed and with two undercoats and a finishing coat. Controller and other cases shall be finished with two coats of an approved aluminium paint on the outside and shall have priming, two undercoats and one finishing coat of paint on the interior. A coating of sprayed molten zinc will be accepted as an alternative to painting of cabinets.

All parts of the signal head assembly shall be finished matt black with white border of the backing boards on the front face only.

All screws and fixing shall be non-corrodible.

2.10 Detectors

Unless otherwise specified, where vehicle actuated signals are required, detectors shall be inductive loops.

---

*Ministry of national development, Department of Highways, Specification For Highway Construction, 1970, Bangkok, Thailand.

Inductive loops shall consist of a loop or loops of insulated conductor, a sensor unit relay and a power source. The loop detector shall operate on the principle that a vehicle standing or crossing over the loop will cause a change in inductance which will be detected by the sensor unit, so operating the detector relay in the signal control. The loop shall be installed in slots cut in the highway surface or laid under the wearing course and the depth, orientation and dimensions of the loop shall be as recommended by the manufacturer. The sensor unit shall be a solid state electronic device capable of sensing changes in the inductance of one or more loops and mounted in a waterproof container which will be located and suitably housed under the roadway or footwalk close to the loop or loops.

The detector shall be so designed, constructed and adjusted that

1) It shall respond only to a vehicle passing over or standing over any portion of the loop.

2) It shall detect vehicles passing over it at speeds up to 100 kph.

3) The detector relay shall be de-energised immediately after a vehicle passes over it.

4) It shall re-balance to ignore parked vehicles and shall thereafter detect subsequent vehicles passing over it.

5) It shall operated normally under any range of weather, temperature and humidity conditions and it shall not be affected by normal variations of line voltages.

6) Where operating as a speed detector which will influence the operation of the controller, the detector shall be fully capable of detecting differences of speed which are consistent with the capabilities of the controller.

Inductive loop detectors shall detect over the entire width of the approach road leaving no gaps of more than 0.4 m. Where required for separate detection, individual detectors will be provided for each traffic

lane, and these shall be so designed and installed that there will be no mutual interference between them.

2.11 Controller

2.11.1 Controller for Traffic Signals

The controller for traffic signal shall be a complete solid state circuitry having replaceable units for ease of maintenance, for controlling the operations of the traffic control signals, including the timing mechanism and all necessary auxiliary equipment, securely mounted in cabinet. Interval timing shall be by electronic and not by mechanical means. The colour sequence of signal indications shall be as given in sub-clause 3.1 and there shall be control to ensure that green will not be shown at the same time on opposing phases under any circumstances. Operation shall be either by fixed time sequences, (variable by time switch) or shall be by vehicle actuation or by combination of both, as specified in the Special Provisions, and as herin described.

The operating voltage shall be as given in the Special Provisions and the controller shall be designed to operate satisfactorily with voltage variations up to + 15.0% or - 20.0% from that specified. The timing of the controller shall be within $\pm$7.5% of correct at the rated voltage and shall not be affected by more than $\pm$10% for a $\pm$10% change in voltage or a $\pm$ 4% change in frequency of the supply.

The controller shall be so designed that temperature variations between 10^{o} C and 70^{o} C shall not change the timing by more than 5%, or otherwise the cabinet shall be artificially ventilated to keep the internal temperature within satisfactory limits. In the event of power failure, the controller shall shut down and re-commence operations without damage and without the necessity for manual re-setting.

The controller shall be provided with suitable mechanism for closing and opening signal circuits, which shall be positive and without

any dark intervals, flickering or conflicting signal indications. All contact points which carry make or break current shall be of fine silver, silver alloy or an alternative better material and shall be capable of carrying, making or breaking a current of 150% of maximum demand load through one million operations without electrical or mechanical trouble.

Every current interrupting device shall be equipped with a suitable radio interference suppressor installed at the input power point. Interference suppressors shall be of design which will minimise interference on both broadcast and aircraft frequencies.

The controller shall provide for the proper phase intervals and sequences as herein specified or as may be required by traffic conditions. The setting of time intervals shall be by means of a positive method against a scale calibrated in seconds. This timing scale shall be easily accessible and indetifiable within the controller and it shall not be necessary to remove or change wires or contacts to adjust the time intervals.

a) Manual Operation

Manual operation shall be possible by means of an approved key or by external buttons on the controller housing. If push buttons are used, they shall be inoperative until the controller has been switched to manual operation by means of a switch mounted under a lockable cover. The automatic operation of the controller shall not be upset by manual operation, and automatic control shall resume without the need for any manual adjustment at the end of manual operation.

Provision shall be made for the following manual operations:

(1) substitution of flashing signals in place of the normal cycle (Where flashing signals have been specified.)

(2) allocating right of way to approaches independently of the pre-set timing of the controller.

(3) switching signals to "OFF"

Provision shall be made that under no circumstances will an approach lose its right of way without having at least the appropriate minimum green time plus amber time.

b. Time Switch

Where a time switch is required this shall be capable of two "ON-OFF" periods per day of a minimum length of sixty minutes each and with a minimum period of sixty minutes between successive "ON - OFF" positions. The setting dial shall clearly distinguish between day and night, and the switching mechanism shall be fitted with a selective device enabling all switching to be eliminated on any one day in the week or early or late switching on two selected days. The week dial shall be clearly marked with the days. The time mechanism shall be fitted with a first quality mechanical movement which shall be electrically wound and shall have a minimum spring reserve of twelve hours.

c) Flashing signals

Where flashing operation is called for, this shall permit either amber or red flashing on any or all approaches. The flashing unit shall generate signal indication at the rate of not more than 60 nor less than 50 per minute, and rapidity of flashes shall remain constant. The illuminated period of each flash shall be approximately equal to the non-illuminated period. A switch or fuse shall be provided which will allow the controller to be isolated and shut down when the flashing signals are in operation.

d) Switches and Fuses

The controller shall be provided with a main switch and fuse which will be isolate the complete installation. There shall be provided one general purpose outlet and fuse. All fuses and switches shall be adequately and permanently labelled.

e) Controller Housing

The controller shall be housed in a weatherproof cabinet of aluminium, sheet metal, glass fibre of other approved material having sufficient strength and rigidity to protect the contents from the effects

of-water, dust and accidental blows. Sheet metal shall be at least 2 mm. in thickness at all points and reinforced where necessary. Ferroue matal shall not be buried and it shall be rust-proofed by galvanising or some other equally effective means. If aluminium or aluminium alloy is used, it shall be suitably protected against electrolytic or chemical corrosion and in the base of the housing it shall contain at least 8 % of silicon.

The housing shall be securely fixed to a concrete base through which connections shall be made to detectors and signals. All doors shall be hinged with concealed hinges, and provided with locks, the door hinges and pins being of non-corrodible metal which shall require lubrication not more often than once per year. Doors shall open and shut freely without binding on the frame or the base. Otherwise, doors may consist of a stiff removable panel having self positioning interlock joints provided with suitable gaskets. Such panels shall be provided with at least two locks. All locks shall be captive, flush-fitting and non-corrodible and shall operate by a standard key which will fit all housing.

The controller shall be sited in such a way that it will not cause on obstruction or hazard to traffic or pedestrians, and where it will not be subject to accidental damage from traffic.

The cables running to signals and detectors shall be terminated in the housing in a convenient and readily accessible position on blocks having the required number of terminals and provided with non-hygroscopic non-inflammable insulating bases. Sufficient space shall be left between terminals and between blocks to enable external cables to enter and be formed in a neat manner without obstructing individual terminal points. Electrical connection between controller and the terminals shall be by approved plug and socket connections.

Each terminal point and connection shall be clearly marked by colour coding or by a numbering system. Ends of all spare conductors shall be taped. Connectors shall be provided with suitable strain relief clamps

wherever necessary. Terminals which are accessible from the doors shall be shielded, covered or insulated so that no live parts will be exposed.

f) Identification

All equipment and replaceable assemblies shall be marked with a part number and any other identification which is required for reordering.

g) Records

The following records shall be provided and kept within the housing, either fixed to the inside of the main door or placed within a metal pocket provided thereon.

(1) A wiring diagram of the system showing the colour coding or number of the conductors.

(2) a layout plan of the intersection showing the detectors, the signals controlled by each phase and the cycle details, and

(3) a suitable ruled card shall be fixed within the controller upon which space is provided to record maintenance under-taken, the data of visit and the name of the person doing the maintenance.

The signal serial number shall be stencilled in two conspicuous locations on the outside of the housing in letters not less than 25mm high.

h) Fixed Time Signal Controller

In addition to the foregoing requirements, where fixed time signals are required, the controller shall be capable of carrying out the following operations, although is shall not necessarily be limited to these:-

(1) allocation of right of way by suitably timed green aspects to the various approaches is accordance with the timings previously set on the controller.

(2) changing from one phase to another by means of the correct sequence of aspects as herein given (3.1) and maintaining the correct pre-set amber periods throughout. It shall be possible to vary the length of intergreen period without use of special tools.

(3) allowing a late start or early cut off on one or more phases as may be specified.

(4) displaying left or right filter arrows as may be specified.

By means of a time switching device, it shall be poesible to alter the phase and cycle lengths to allow for varying traffic conditions. It shall be possible to operate at least three such programes during a period of 24 hours.

It shall be possible to integrate the controller into a linked system working under a master controller of required, and to add a facility for vehicle counting. The sequence of phase shall be capable of alteration without any modification to the controller. When specified, it shall be possible automatically to dim the traffic signal lights during the hours of darkness.

I) Vehicle-actuated Signal Controller

In addition to the foregoing requirement, where vehicle actuation is called for, the controller shall be capable of, but not necessarily limited to the following operations.

(1) In the absence of detector actuation, the right of way shall remain on the phase on which the last demand was made. However, a recall switch shall be incorporated into each phase which, when closed, will result in the right of way automatically returning to that phase without further demand. (Automatic Reversion)

(2) When the right of way is transferred to a phase in response to a demand, this right of way shall continue for at least a per-set and adjustable minimum period (Minimum Green Time)

(3) Continued demands beyond a predetermined number on a phase having the right of way shall cause the initial minimum right of way period to be extended, the extension being proportional to the additional demands. (Vehicle Extension Periods)

(4) In the absence of demands from other phases continued demands on the phase having the right of way shall hold that right of way. When a demand is made from another phase, the phase holding the right of way shall lose it, even in the event of continuing demands, after a pre-set adjustable

maximum period (Maximum Green Period). The timing of the maximum green period shall commence from the first receipt of a demand from another phase.

(5) Should there be outstanding demands on the phase losing the right of way or should further demands be made on a phase during the clearance period, then right of way shall revert automatically to the phase losing it once demands of other phases have been satisfied.

(6) The transfer of right of way shall take place only after an adjustable clearance period, which may differ between different phases. (Inter-green Period)

(7) Provision shall be made for green filter arrows and late-start or early cut-off facilities on any phase. If these are not required at the outset, there shall be provision for their inclusion at a later stage if required.

(8) It shall be possible to incorporate the controller into a linked system under a master controller if required, and there shall be facilities for resumed independent operation either on a time basis or as result of altered traffic conditions.

(9) Traffic counting and queue detection, if not specified, may be required at a later stage, and facilities for these should be incorporated or it should be possible to add them easily when required.

j) Vehicle actuated Controller with speed measuring equipment

When the controller is to be used with speed measuring detector, the following additional facilities will be required on the controller, as well as items (1) to (9) above:-

(1) The minimum green time refered to in I(2) above shall be reduced according to the number of demands that have been made below the predetermined number [I(3)]so that if there are less than the predetermined number of vehicles waiting for the right of way, only sufficient time will be given for that number to clear the junction beforeright of way is given to another phase that has made a demade. (Variable minimum green time)

(2) The vehicle extension period [I(3)] above shall be variable

in length and not fixed, the length of each vehicle extension period being inversely proportional to the speed of the vehicle making the demand at the detector pad. (Variable vehicle extension period)

(3) If a demand is made on a phase not having the right of way and all demands have been met on the phase having the right of way then the right of way shall be given to the phase making the demand after a minimum inter-green period. However, if at the expiration of the maximum green period on the phase having the right of way there are still vehicle extension periods outstanding, the inter-green period shall be lengthened by the introduction of an all-red period if required to ensure that the right of way is not given to an opposing phase before fast traffic has cleared the junction on the phase losing the right of way. (Variable Inter-green period)

2.11.2 Flash Control Unit (for flashing traffic signals only)

The flash control unit shall consist of a compact and complete unit which shall operate by switching the ungrounded side of the A.C.mains. It shall not include nor depend upon any mechanical or electromechanical operations, the entire control and switching action being done by means of solid state electronic devices. The control unit shall be capable of controlling either one or two lamp circuits, the maximum load on any circuit being not more than one Kilowatt. The power input to the control unit shall not exceed five Watts over and above the circuit load at nominal voltage.

Every current interrupting device shall be equipped with a suitable radio interference suppressor installed at the input power point. Interference suppressors shall be of a design which will minimise interference on both broadcast and aircraft frequencies.

The control unit shall produce flashing of the optical systems to which it is connected at the rate of between 50 and 60 flashes per minute. This rate shall not very by more than two per cent at any time at constant temperature, nor by more that two per cent due to the range of

ambient temperarture normally experienced in Thailand. The illuminated period of each flash shall be approximately equal to the non-illuminated period, and when two circuits are controlled the illuminated periods shall be of the same length for both circuits. The control unit shall be housed in a weather and dust proof housing of aluminium sheet metal, glass fibre or other approved material having sufficient strength and rigidity to protect the contents from the effects of water, Dust and accidental blows. Sheet metal shall be at least 2 millimeters in thickness at all points and reinforced where necessary. Ferrous metal shall not be buried and shall be rust proofed by galvanising or some other equally effective means. Aluminium or aluminium alloy shall be suitable protected against electrolytic and chemical corrosion and shall contain at least 6% of silicon.

The control unit housing shall be securely mounted on the signal pedestal or other approved position by means of corrosion resistant bolts or fastenings. The inspection door shall be hinged with concealed hinges the hings pins being corrosion resistant metal. Otherwise,a stiff removable panel may be provided having self positioning interlock joint and a suitable gasket. A captive flush fitting and corrosion resistant lock shall be provided, complete with keys for either door or panel, whichever is proposed. The cables running to the signal heads shall be terminated in the housing in a convenient and readily accessible position on a block or blocks having the required number of terminals and provided with a non-hygroscopic and non-inflammable base. Sufficent space shall be left between terminals and between blocks to anable cables to anter and to be formed neatly without abstructing individual terminal points. Electrical connections between the terminal block or blocks and the control unit shall be by approved plug and socket connections.

Each terminal point and connection shall be clearly marked or colour coded. Ends of all spare conductors shall be taped. Connectors shall be provided with suitable strain relief clamps where necessary. Terminals

which are necessible from the inspection opening shall be shielded, covered or insulated so that no live parts will be exposed.

The control unit shall be provided with a main switch and fuse within the housing which will isolate the complete installation.

3 Design Principles

This clause is intended to give general guidance in the principles to be followed in design where the Bidder of Contractor is required to undertake this function.

3.1 The sequence of aspects on any one signal face shall be:

Red

Green

Amber

During any aspect, there shall be no visual flicker of the signal illumination.

3.2 Sitting of signals

Siting of signal will be carried out in detail at the junction and shall be agreed by the Engineer. Each approach road shall be served by a minimum of two signal faces as follows.

The Primary Signal which will be located not less than 1.0 meter beyond the Stop Line on the nearside of the road. Where there is a central median, a second primary signal may be provided similarly on the offside of the approach, and

The Secondary Signal which will be on the diagonally oposite side of the junction facing the approach, that is,on the back of the primary signal serving the opposite approach in the case of a four arm junction. The secondary signal may be opposite the offside of the approach where there is a central median, but in any case should not be outside an angle of 30^{0} extended from the center line of the approach at the Stop Line to the offside. Where the distance from the Stop Line to the secondary signal is

more than 50 m. additional secondary signals should be provided. No part of any signal or post shall be within 0.5 m. of the kerbline.

3.2.1 Height of Signal

The height of fixed light signals shall be such that when erected the center of the amber optical system shall be not less then 2.4m nor more than 4 m above the carriageway level. For portable light signals, the corresponding height shall be not less than 1.5 m nor more than 2.6 m.

Signals mounted overhead shall be such that when erected the clearance for traffic shall be not less tan 5.25 m.

Variations from the minimum height should only be contemplated when there are definit reasons for making such variation obligatory.

3.2.2 Direction of Beam

The light signals shall be directed at a point approximately 100 m from the primary signal face and approximately 1.5 m above ground level at the center line of the carriageway allocated to approaching traffic. Where signals are overhead-mounted above the carriageway, the corresponding distance shall be 200 m. These dimensions may be varied where special circumstances require otherwise.

3.3 Stop Lines

Stop Line shall be located as shown on the site layout plan

3.4 Detectors

Detector, where vehicle actuation is specified, shall be not more than 45 m nor less than 30 m from the stop line on each approach, although on difficult approaches carrying only slow traffic, this minimum may be reduced to 20 m. On high speed roads, where second detectors are called for, these shall be placed at not more than 165m. from the stop line.

3.5 Phases

The number of phases at the intersection shall be kept to the minimum required to avoid dangerous conflict of traffic. Where additional phases are called for by unusual traffic conditions at certain times, these additional phases shall be suppressed when not required. In designing the number of phases and the details of the cycle, the principle shall be to arrive at the arrangement which will at all times give minimum average delays to traffic with adequate capacity and maximum safety to both vehicles and to pedestrians.

3.6 Filter Signals

Filter Signals mounted at the side of the main signals may be used to allow a movement in one direction. Particular care shall be taken to ensure that filtering traffic does not form an undue hazard to pedestrians crossing and guard rails, slip roads, islands or some resiting of the stop line may be required to avoid this. Filtering traffic will not be permitted when it will have to merge with through traffic. Where an early cut-off is used for offside turning traffic, an offside filter arrow will be provided to indicate to turning traffic that it is safe to proceed.

3.7 Clearance Period

Clearance Periods shall have a minimum length of three seconds. Where required for safety or to allow turning traffic to clear a longer clearance period may be introduced but this should be kept to the shortest period which is consistent with the demands of traffic and safety at any time.

3.8 Linked Systems

When a linked system is called for, or where linking with nearby signals appears desirable, this system shall be designed to give a progression of green periods in both directions along the routes involved and at

apeeds which will give high capacity. The speeds through the system shall be as uniform as possible and the demands of cross traffic shall be fully met. With fixed time signals, there shall be the facility to change automatically the programme of linking, if necessary, so as to give preference to the heavier flows at different times of the day. With vehicle actuated signals, local controllers shall be free to revert to independent operation when there ceases to be a continuous demand providing that this will not interfere with the overall progression through the system. All calculation done for linked systems will be submitted for checking.

3.9 Signal Timing

Signal Timing will be done on the basis of traffic demands as estimated from the traffic flows. Verification and adjustment will be required on site after the system is in operation but the Contractor must show by calculations capable of handling the estimated maximum and normal flows in an efficient manner and with minimal delays. With fixed time signals, he will submit details of phases and cycles for each approach throughout the day. In the case of vehicle actuated signals, he will give similar details of maximum cycle time, manimum and minimum green times, vehicle extension periods and inter-green periods.

4. Construction Methods

4.1 Excavation and Reinstatement

Excavation for cable or conduit laying or for foundations and reinstatement shall be carried out in accordance with the provisions of Section 2.5 of these Specifications Reinstatement shall be such that the surface is restored to at least its original condition and level.

4.2 Concrete Work

All necessary foundations and footings or other concrete work

shall be carried out in accordance with Sections 5.1 and 5.2 of these Specifications. Unless otherwise specified on the Drawings or in the Special Provisions, concrete shall be class B. Foundations shall be placed in one operation except that the top 50 mm. may be placed after the superimposed structure is in position. The exposed portions of foundations shall be formed to present a neat and tidy appearance and sloped to shed water away from the structure supported. Where existing obstructions prevent the construction of foundations as shown on the plans, then an effective alternative may be provided subject to the prior approval of the Engineer.

4.3 Conduits, Fittings and Boxes

Conduits, fittings and boxes shall be provided and installed in accordance with the provisions of Section 5.11 of these Specifications* except that chemically stable, tough plastic conduits, fittings and boxes, according to samples previously approved by the Engineer, will be permitted providing that they do not soften when exposed to high ambient temperature.

The Contractor may use a larger size of conduit than that specified, at no extra charge, if he wishes, but in this case the entire run shall be of the same size. No reducing couplings will be permitted.

When metal conduits are used, cuts shall be made square and true and all couplings shall be screwed up until the ends of the conduits are brought together in order to provide a good electrical contact throughout. The threads on all ferrous metal conduits shall be painted with a rust preventing paint before couplings are made up. Where the coating on ferrous

---

* Ministry of National Development, Department of Highways, Specification For Highway Contruction, 1970, Bangkok, Thailand.

metal conduit has been damaged in handling, such damaged places shall be painted with rust preventing paint before installation.

All conduit ends shall be threaded and capped until wiring is started. When caps are removed, the threaded ends shall be provided with approved conduit bushings.

Conduit shall be laid to a depth of not less than 0.5m below paved footwalks and medians and not less than 0.75 m below the roadway surface. The location of all conduits at curb lines shall be marked by means of a "Y" at least 100 mm high incised in the face of the curb directly above the conduit. Conduit terminating in standards, cabinets or pedestals shall extend at least 50 mm vertically above the foundations and shall be sloped towards the hand-hole opening. Conduit entering pull boxes shall terminate at least 50 mm inside the box wall and at least 50 mm vertically above the bottom of the box. Such conduit shall be sloped towards the top ot the box to facilitate pulling. Conduit entering the bottom of the box shall enter near the sides or end to leave the centre clear. All conduit shall enter in the direction of the run.

4.4 Pull Boxes

Pull boxes shall be installed as shown on the plans and in any case at not more than 60 m intervals. The Contractor may install additional pull boxes without extra charge if he wishes. Pull boxes shall be of reinferced concrete not less than 100 mm thick and may be of approved precast design. Reinforced concrete covers, secured by two recessed brass bolts shall be used on footwalks, the covers being inscribed "Traffic Signals" on the outside. Under the roadway, covers shall be of steel or cast iron, inscribed as specified above, and laid in a suitable concrete footing to withstand traffic loads. Metal covers shall be effectively earthed to an earthing rod inside the box. Tops of pull boxes shall be effectively level with the surrounding paved areas, whether footwalk or

roadway, but in unpaved areas, the tops of pull boxes shall be buried 0.3 m below ground level. The bottom of pull boxes shall be bedded in sand and cement or crushed rock. Permanent markers shall be provided and erected to show the position of all pull boxes.

5. Testing

A functional test shall be made on completion of the work in order to demonst e that every part of the equipment and installation functions as intended and specified. This test shall consist of not less than five days continuous and satisfactory operation. If any defects or unsatisfactory operation are revealed, this condition shall be corrected and the test continued until required five days of satisfactory operation have been performed.

Prior to the functional test, the Contractor shall carry out the following tests to the antire satisfaction of the Engineer,

i) Each circuit shall be tested for continuity

ii) Each circuit shall be tested for earthing

iii) A "megger" test shall be made between each circuit and earth. The insulation resistance shall be shown to be at least that specified within the relevant Codes. On the completion of testing, the Contractor shall supply to the Engineer three copies of "as built" plans and circuit diagrams, which shall clearly indicate any modification which have been made to the original design.

6. Measurement

This item will not be measured, payment being made on a lump sum basis.

7. Payment

The lump sum payment for the traffic signal system shall be full compensation for furnishing all labour, materials, tools, equipment, supervision and incidentals and for doing all the work involved in furnishing and installing the system shown on the Drawings and as specified herein and in the Special Provisions, and as directed by the Engineer, including any necessary backfill, concrete foundation, restoration of footwalk, roadway, curbing and appurtenances damaged or destroyed during construction and in making all tests. It shall also cover the costs of design if this is called for.

The lump sum payment shall be deemed to include full compensation for all additional materials and work not shown on the Drawing or specified which are necessary to complete the installation.

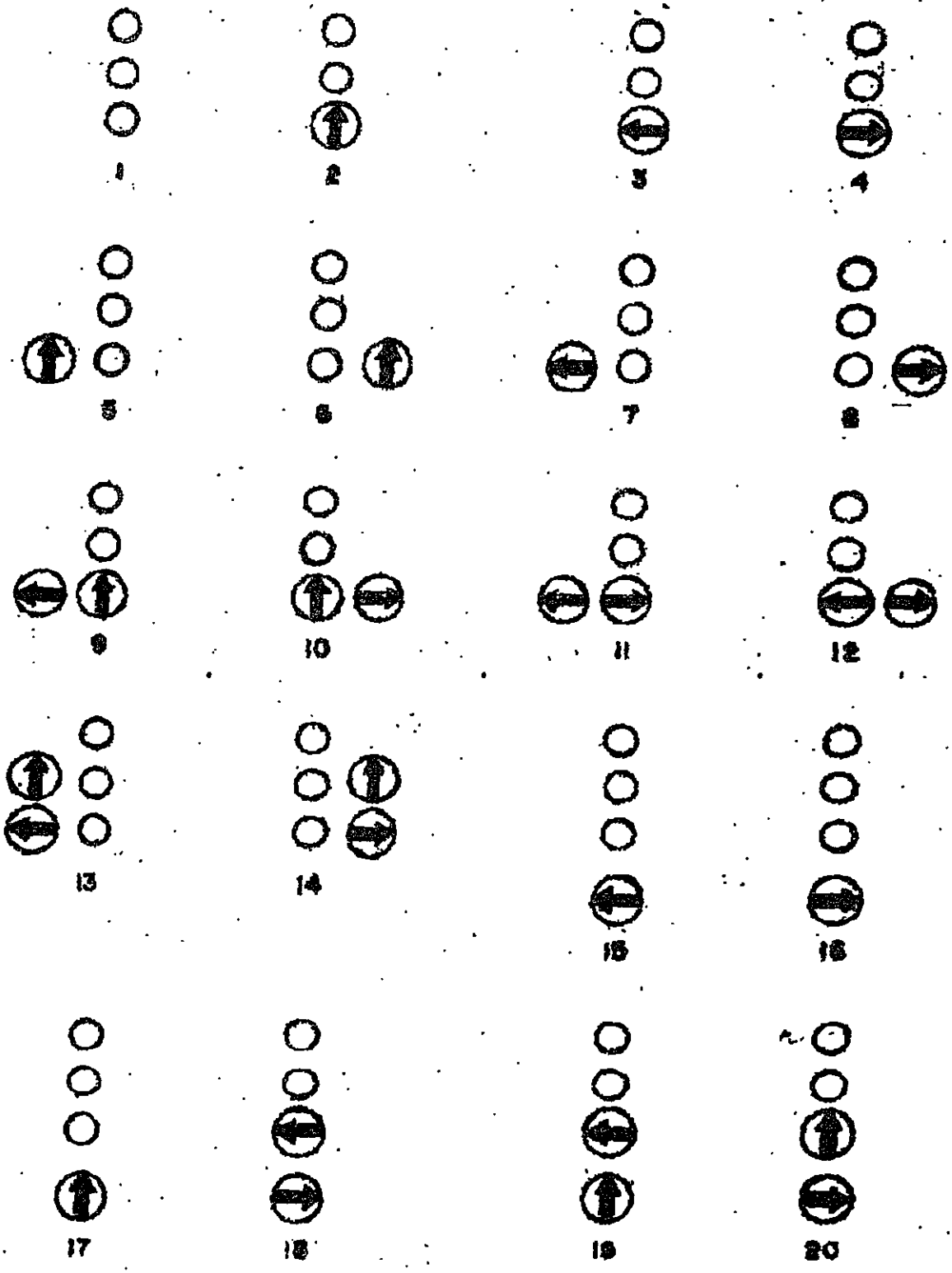

Fig. 1 Permitted arrangements of signal faces.