



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

GUIDELINES FOR THE MAINTENANCE OF TRAFFIC SIGNAL SYSTEMS

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ABSTRACT

These guidelines were developed to establish levels of maintenance capabilities required for traffic signal systems and equipment with different levels of sophistication.

Maintenance was classified into three categories: Preventive, Response and Design Modification. Preventive Maintenance was divided into two levels based on a set of procedures to be implemented at scheduled intervals. Response Maintenance was classified into three levels based on equipment complexity and personnel capabilities. Time estimates to respond to an intersection response call and to repair the problem were defined. Also developed were a list of equipment inventory requirements and record keeping and documentation procedures.

A comparison was made between performing the maintenance and repair by municipal forces or by private contractor. Typical specifications were developed for contractor maintenance.

A check list and an evaluation form were developed to aid in evaluation of a municipality's maintenance capabilities.

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INTRODUCTION

The purpose of this manual is to establish general guidelines for maintenance of traffic signal systems including control equipment, signals, poles and other related hardware.

BACKGROUND

Available information on maintenance was researched using the National Technical Information Service Search (i.e. NTISearch). Edwards and Kelcey provided the Department with a list of "key words" necessary for the computer search and reviewed both abstracts and complete articles. No specific information was found pertaining to maintenance practices with respect to manpower and equipment.

Subsequently, Edwards and Kelcey developed questionnaires to obtain information from municipalities as to their maintenance practices, present and projected requirements, operating equipment, testing facilities, and budgetary and manpower requirements. Two sets of questionnaires were prepared, a short form (EK-12) and a long form (EK-29), and were sent to a group of representative municipalities. All responses were tabulated and evaluated.

The responses varied considerably among municipalities. Field trips were made to examine maintenance records and to verify the responses for the municipalities of Wilkensburg, Reading, Lock Haven, Allentown and Philadelphia. In addition, members of the project team met with various municipalities outside Pennsylvania, which are proficient in maintenance of traffic control signal equipment, to obtain supplementary information.

THIS REPORT

This report is divided into 7 Sections as follows:

Overall Maintenance Classifications and Levels (Section 1.0)

It was apparent from the response to questionnaires and research that the same word often had different meanings to different individuals. Therefore, it was necessary to establish standards and maintenance was divided into the following major categories:

- (1) Preventive
- (2) Response
- (3) Design Modifications

Preventive Maintenance is defined as providing periodic checks and procedures to assure reliable operation of traffic signal equipment which will reduce field failures. Response Maintenance is the repair and return to normal operation of failed equipment. Design Modification is any change to the approved design and operation of a traffic signal which is justified due to a recurring problem.

The Overall Level of Maintenance can be determined by evaluating the various levels of Preventive Maintenance (Section 2.0) and Response Maintenance (Section 3.0).

Preventive Maintenance (Section 2.0)

Preventive Maintenance was categorized into two levels: the minimum maintenance for a reliable operation and the maintenance for both aesthetics and reliable operation. Tasks necessary for each level of preventive maintenance were defined and the estimated time to perform these tasks was summarized. In addition, a detailed description by item was developed to aid the signal mechanic/technician in providing preventive maintenance.

Response Maintenance (Section 3.0)

Response Maintenance was categorized into three levels based on the complexity of the equipment, personnel capabilities and test and repair facilities. The most important consideration was to have a constant repair response time, regardless of the level of sophistication of the equipment. This was achieved by developing a priority repair list for emergency repair (temporary) and final repair (conform to permit).

Manpower (Section 4.0)

Personnel capability was determined to be a key factor in the development of the levels of maintenance. Therefore, traffic signal maintenance personnel were divided into the following four categories based on their responsibilities, knowledge and skills.

- (1) Signal Mechanic
- (2) Supervising Signal Mechanic
- (3) Signal Technician
- (4) Signal Specialist

An organizational chart was prepared to show this relationship and to provide general guidelines for appraising existing personnel and organization structure, or to establish a future maintenance organization.

Annual Costs (Section 5.0)

This section of the report can provide a municipality with quantitative and qualitative guidelines for manpower and equipment costs of response and preventive maintenance. To accomplish this task estimates for annual productive work hours, time distribution requirements per intersection, annual cost for a signal mechanic, service response time and a price list for replacement equipment were prepared. These estimates should be adjusted based on a municipality's needs to determine actual annual costs.

Maintenance Forms (Section 6.0)

One of the most important but often neglected requirements of the traffic signal maintenance is relevant and up-to-date documentation. Documentation includes as-built plans, wiring schematics, component layout sheets, time/dial setting sheets, cam breakout sheets, conflict monitor programming sheets, manuals, failure records, preventive maintenance records, etc. Analysis of maintenance records can help in providing efficient service, scheduling and strategies, and may protect the municipality in case of a legal suit. Records were developed to provide relevant information on preventive maintenance and response maintenance.

Contractor Maintenance (Section 7.0)

Municipalities that do not have in-house expertise to service some or all of the signalized intersections, may hire an experienced traffic signal maintenance contractor to perform the maintenance function. Questionnaire EK-39 was prepared to research information on the practices and services of these Contractors. The questionnaire was sent to selected maintenance contractors and included questions on manpower, facilities, experience and hourly rates.

Contractor maintenance recommendations were developed using this information and levels previously established for both response and preventive maintenance. These levels of maintenance may be accomplished by different means and are depicted in "Contractor Maintenance Options". The municipality should choose the option that is most appropriate.

1.1 MAINTENANCE CLASSIFICATIONS AND LEVELS

Maintenance of Traffic Signal Systems can be classified into the following categories:

1. **Preventive Maintenance.** This involves a set of procedures to be performed at scheduled intervals for the upkeep of traffic signal systems. It includes the inspection, record-keeping, cleaning or replacement based on the function and rated service life of the component. Some of the major items under this category are:

- o group relamping
- o signal lens cleaning
- o signal head alignment
- o detector amplifier tuning
- o visual inspection and verification of the signal control operation and equipment.

This category includes any redesign of the control equipment to eliminate a recurring problem. Preventive maintenance will minimize the probability of a failure requiring response maintenance.

2. **Response Maintenance.** This involves procedures and actions taken in case of failure of traffic signal and control equipment in the field, to keep the intersection and/or system operational. It also involves troubleshooting and record-keeping of equipment returned from the field.
3. **Design Modification.** This involves a design modification to implement or omit a movement or other special functions, or a change in the signal display to correct any problems resulting from a new installation.

The overall level of maintenance as defined in Table 1-1 can be determined by evaluating the various levels of Prevent Maintenance (Section 2.0) and Response Maintenance (Section 3.0).

Table 1-1

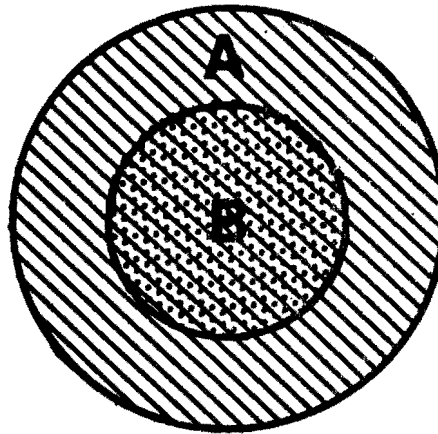
LEVELS OF OVERALL MAINTENANCE

<u>LEVEL OF OVERALL MAINTENANCE</u>	<u>PREVENTIVE MAINTENANCE LEVEL</u>	<u>RESPONSE MAINTENANCE LEVEL</u>
I	A	A
II	A or B	B
III	B	C

2.1 DEFINITION OF PREVENTIVE MAINTENANCE LEVELS

Preventive Maintenance can be divided into 2 levels as defined below and depicted in Figure 2-1.

FIGURE 2-1



PREVENTIVE MAINTENANCE

LEVEL A: Level A includes items listed as A and B in the Preventive Maintenance Summary (Section 2.2). This is the recommended level of maintenance to keep intersection control equipment and signals in a dependable, structurally safe and aesthetically good condition.

LEVEL B: Level B includes items listed as B in the Preventive Maintenance Summary. This level of maintenance includes the minimum requirements for the operation of intersection control equipment and signals.

Even though Level B results in reduced budget costs, it may be a false savings resulting in detrimental long term effects and large capital expenditures.

Table 2-1.

PREVENTIVE MAINTENANCE LEVELS

		<u>Personnel Classification</u>
LEVEL A	<u>RECOMMENDED</u>	
	See Preventive Maintenance Summary For Details	<u>Signal Mechanic</u>
LEVEL B	<u>MINIMUM FOR RELIABLE OPERATION</u>	
	See Preventive Maintenance Summary For Details	<u>Signal Mechanic</u>

2.2 PREVENTIVE MAINTENANCE SUMMARY

		Maintenance Interval			
		Months		Years	
		3	6	12	2-5
<u>MECHANICAL</u>					
<u>CABINET</u>					
o	paint				A
o	oil hinges and lock			A	
o	clean filter		A		
o	replace filter			B	
o	check weatherproof seal (gasket)			A	
o	check anchor bolts			A	
o	check for gas, water accumulation, duct sealant			B	
o	check ground rod clamp			A	
o	wiring schematics and report available and signed			A	
o	check operation of fan and heater		A		
<u>SIGNAL HEADS</u>					
o	paint exterior of signal				A
o	clean lenses, signs and reflectors			B	
o	replace lamps			B	
o	check alignment		A	B	
o	check for wear on the span wire and the signal wire; check the mechanical hardware (clevis pin, clamps)			A	
o	check mast arms: free swinging signals - check clevis and the chain			A	
o	check for cracks or rust in the hardware			A	
o	check bent hoods, wing nuts, hinges		A	B	
o	replace any parts not up to standard		A		
o	check locking ring (surface); install proper locking devices as required			A	
o	perform a nighttime check for visibility		A	B	

Maintenance Interval			
Months		Years	
3	6	12	2-5

MAST ARMS AND POLES

- | | |
|--|---|
| o paint | A |
| o inspect for rust and spot paint as required | A |
| o inspect the joints for rust and cracks | |
| - at arm/upright location | A |
| - at base plate | A |
| o inspect anchor bolts for rust and tightness | A |
| o inspect the horizontal and vertical angle of the arm | A |

SPAN WIRE AND POLES

- | | |
|------------------------------------|---|
| o refer to applicable pole section | |
| o check span wire | A |
| o check clamps, hardware | A |
| o check guy wire and the anchor | A |

PUSH BUTTONS

- | | |
|---|---|
| o check push button on each end of actuated crosswalks and visually verify pedestrian signal operation; verify timing | B |
| o check push button lamp (if exists) for operation | B |
| o check push button signs and clean if necessary | B |
| o check push button signs alignment | B |

DETECTOR SENSORS

- | | | |
|---|---|---|
| o make a visual inspection of the roadway along the saw cut for exposed wires, cracks, potholes, etc. | A | B |
| o check alignment for sonic, magnetic and radar type detectors | A | B |
| o check anchorage for pressure detector frame | A | B |

Maintenance Interval			
Months			Years
3	6	12	2-5

UNDERGROUND

JUNCTION BOXES AND HANDHOLES

- | | | |
|---|--|---|
| o | check the integrity of the splices | A |
| o | check the ground rod and clamp connection, and bonding of conduits | A |
| o | check the insulation | A |
| o | check for abnormal amount of water | A |
| o | check lid for abnormal condition and fit | A |

ELECTRICAL

- | | | |
|---|--|---|
| o | check radio interference filter and lightning arrestor | A |
|---|--|---|

ELECTROMECHANICAL CONTROL EQUIPMENT

Dial Assembly

- | | | |
|---|---|---|
| o | check for wear on key follower | B |
| o | check for burned or pitted contacts and service contacts per manufacturer maintenance recommendations | B |
| o | check for key positions | B |
| o | check for cycle gear size and mesh | B |
| o | check dial motor operation | B |
| o | check all dials according to manufacturer's recommendations | B |
| o | if controller is part of a system, test offset | B |
| o | check duration of the advance pulse | B |

Cam Assembly

- | | | |
|---|---|---|
| o | check for end play | B |
| o | clean and lubricate as required by manufacturer | B |
| o | visually inspect for abnormal wear or cracks | B |
| o | visually inspect contacts for pitting/discoloration and service contacts per manufacturer maintenance recommendations | B |
| o | check spring tension on contacts | B |

Maintenance Interval			
Months		Years	
3	6	12	2-5

- o check for any loose wiring contacts B
- o check for operation of advancing mechanism to conform with manufacturer's requirement B
- o check if all connections are secure and tight B
- o visually inspect wires for wear, rubbing, deterioration of insulation B

Relays

- o check for burned and pitted contacts and service contacts per manufacturer's maintenance recommendations B
- o check for tight and secure fit into the sockets B
- o if latch type relays check for latch operation as per manufacturer's recommendations B

Flashers

- o check flash rate B
- o check operation B
- o service contacts per manufacturer's recommendation B
- o check for tight and secure fit into sockets B

Switches

- o verify operation of each switch position B

Terminal Connections

- o check visually for signs of corrosion or any abnormal condition B
- o tighten all terminal connections B

Conflict Monitor

- o refer to solid state section

Detector Amplifiers

- o refer to solid state section

Maintenance Interval

Months			Years
3	6	12	2-5

**SOLID STATE, ANALOG, AND MICROPROCESSOR BASED
CONTROL EQUIPMENT**

- o check if the time settings match the master time sheet B
- o check if all indicator lamps on the modules are working; replace failed lamps A
- o check for extension by detector actuation B
- o check if the modules are fitting tight and secure into the frame B
- o check if the connector is tight and secure B

Load Switches

- o check if load switch packs are fitting tight and secure into the chassis B

Conflict Monitor

- o jump two conflicting green phases and check if conflict monitor responds; if it does, check if stop timing is implemented B
- o if auxiliary logic package exists in the controller, check if conflict monitor detects a 24 VDC level drop B
- o check if flash is activated B

Flashers

- o refer to electromechanical section

Switches

- o refer to electromechanical section

Terminal Connections

- o refer to electromechanical section

Relays

- o refer to electromechanical section

Maintenance Interval

Months			Years
3	6	12	2-5

Auxiliary Logic

- o check to ensure that the points of connection are making good contact B
- o if electromechanical device, check for any wear; if contacts are used, cleaning may be required per manufacturer's recommendations B

Detector Amplifiers

- o check if the detector is detecting vehicles within its design zone of detection A B
- o tune the detector if necessary A B
- o check if the connectors are tight and secure A B

INTERCONNECTED EQUIPMENT

- o check if controller operates in the mode selected by the supervisory master B
- o disconnect from the master supervisory system and check for "free" or backup operation B
- o check any special equipment per manufacturer's recommendations B

GENERAL

- o record all changes in: timing, wiring, or any function AS REQUIRED
- o periodically check the electric bill for leaky insulation AS REQUIRED

2.3 Time Estimates For
PREVENTIVE MAINTENANCE SUMMARY

ABBREVIATIONS

M Minutes
H Hours

Maintenance Interval

Months		Years	
3	6	12	2-5

MECHANICAL

CABINET/Per Unit

o paint				A(3H)
o oil hinges and lock				A(5M)
o clean filter	A(2M)			
o replace filter				B(2M)
o check weatherproof seal (gasket)				B(2M)
o check anchor bolts				A(2M)
o check for gas, water accumulation, duct sealant				B(2M)
o check ground rod clamp				A(1M)
o wiring schematics and report available and signed				A(1M)
o check operation of fan and heater	A(2M)			

<u>Unit Total</u>	<u>4M</u>	<u>14M</u>	<u>3H</u>
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SIGNAL HEADS/Per Unit

o paint exterior of signal				A(1H)
o clean lenses, signs and reflectors				B(10M)
o replace lamps				B(2M)
o check alignment	A(5M)			B
o check for wear on the span wire and the signal wire; check the mechanical hardware (clevis pin, clamps)				A(3M)
o check mast arms: free swinging signals - check clevis and the chain				A(3M)
o check for cracks or rust in the hardware				A(2M)
o check bent hoods, wing nuts, hinges	A(2M)			B
o replace any parts not up to standard	A(2M)			

o check locking ring (surface); install proper locking devices as required				A(5M)	B
o perform a nighttime check for visibility	<u>Unit Total</u>	<u>22M</u>	<u>12M</u>	<u>1H</u>	
/per approach		(10M)			B

Maintenance Interval			
Months		Years	
3	6	12	2-5

MAST ARMS AND POLES / Per Unit

o	paint	A(8H)
o	inspect for rust and spot paint as required	A(8M)
o	inspect the joints for rust and cracks	
	- at arm/upright location	A(5M)
	- at base plate	
o	inspect anchor bolts for rust and tightness	A(5M)
o	inspect the horizontal and vertical angle of the arm	A(2M)
Unit Total		20M 8H

SPAN WIRE AND POLES / Per Unit

o	refer to applicable pole section	
o	check span wire	A(10M)
o	check clamps, hardware	A(5M)
o	check guy wire and the anchor	A(5M)
Unit Total		20M

PUSH BUTTONS / Per Unit

o	check push button on each end of actuated crosswalks and visually verify pedestrian signal operation; verify timing	B(5M)
o	check push button lamp (if exists) for operation	B(2M)
o	check push button signs and clean if necessary	B(5M)
o	check push button signs alignment	B(3M)
Unit Total		15M

DETECTOR SENSORS / Per Sensor

o	make a visual inspection of the roadway along the saw cut for exposed wires, cracks, potholes, etc.	A(5M) B
o	check alignment for sonic, magnetic and radar type detectors	A(5M) B
o	check anchorage for pressure detector frame	A(2M) B

Maintenance Interval			
Months		Years	
3	6	12	2-5

UNDERGROUND

JUNCTION BOXES AND HANDHOLES / Per Unit

- o check the integrity of the splices
- o check the ground rod and clamp connection, and bonding of conduits
- o check the insulation
- o check for abnormal amount of water
- o check lid for abnormal condition and fit

A
A
A
A
A
(10M)

Unit Total 10M

ELECTRICAL

- o check radio interference filter and lightning arrestor

ELECTROMECHANICAL CONTROL EQUIPMENT

Dial Assembly

- o check for wear on key follower
- o check for burned or pitted contacts and service contacts per manufacturer maintenance recommendations
- o check for key positions
- o check for cycle gear size and mesh
- o check dial motor operation
- o check all dials according to manufacturer's recommendations
- o if controller is part of a system, test offset
- o check duration of the advance pulse

A
B
B
B
B
B
B
B
(8H)

Cam Assembly

- o check for end play
- o clean and lubricate as required by manufacturer
- o visually inspect for abnormal wear or cracks
- o visually inspect contacts for pitting/discoloration and service contacts per manufacturer maintenance recommendations
- o check spring tension on contacts

B
B
B
B
B
B

		Maintenance Interval			
		Months		Years	
		3	6	12	2-5
o	check for any loose wiring contacts			B	
o	check for operation of advancing mechanism to conform with manufacturer's requirement			B	
o	check if all connections are secure and tight			B	
o	visually inspect wires for wear, rubbing, deterioration of insulation			B	
<u>Relays</u>					
o	check for burned and pitted contacts and service contacts per manufacturer's maintenance recommendations			B	
o	check for tight and secure fit into the sockets			B	
o	if latch type relays check for latch operation as per manufacturer's recommendations			B	
<u>Flashers</u>					
o	check flash rate			B	
o	check operation			B	
o	service contacts per manufacturer's recommendation			B	
o	check for tight and secure fit into sockets			B	
<u>Switches</u>					
o	verify operation of each switch position			B	
<u>Terminal Connections</u>					
o	check visually for signs of corrosion or any abnormal condition			B	
o	tighten all terminal connections			B	
				<u>Unit Total</u>	
				8H	
<u>Conflict Monitor</u>					
o	refer to solid state section				
<u>Detector Amplifiers</u>					
o	refer to solid state section				

Maintenance Interval			
Months		Years	
3	6	12	2-5

SOLID STATE, ANALOG, AND MICROPROCESSOR BASED CONTROL EQUIPMENT/Per Unit

o check if the time settings match the master time sheet	B(5M)	
o check if all indicator lamps on the modules are working; replace failed lamps		A(5M)
o check for extension by detector actuation	B10M	(10M)
o check if the modules are fitting tight and secure into the frame		B(2M)
o check if the connector is tight and secure		B(3M)
<u>Unit Total</u>	<u>10M</u>	<u>10M</u>

Load Switches/Per Unit Controller

o check if load switch packs are fitting tight and secure into the chassis	B(5M)
<u>Unit Total</u>	<u>5M</u>

Conflict Monitor/Per Unit

o jump two conflicting green phases and check if conflict monitor responds; if it does, check if stop timing is implemented	B(5M)
o if auxiliary logic package exists in the controller, check if conflict monitor detects a 24 VDC level drop	B(3M)
o check if flash is activated	B(2M)
<u>Unit Total</u>	<u>10M</u>

Flashers

o refer to electromechanical section	(5M)
--------------------------------------	------

Switches

o refer to electromechanical section	(5M)
--------------------------------------	------

Terminal Connections

o refer to electromechanical section	(5M)
--------------------------------------	------

Relays

o refer to electromechanical section	(10M)
<u>Total</u>	<u>25M</u>

Maintenance Interval

Months			Years
3	6	12	2-5

Auxiliary Logic/Per Unit

- o check to ensure that the points of connection are making good contact B(5M)
- o if electromechanical device, check for any wear; if contacts are used, cleaning may be required per manufacturer's recommendations B(10M)

Unit Total	15M
------------	-----

Detector Amplifiers/Per Channel

- o check if the detector is detecting vehicles within its design zone of detection A(15M) BPer Channel
- o tune the detector if necessary A(3M) BPer Channel
- o check if the connectors are tight and secure A(2M) BPer Channel

Unit Total	20M
------------	-----

INTERCONNECTED EQUIPMENT/Per Unit

- o check if controller operates in the mode selected by the supervisory master (5M) B
- o disconnect from the master supervisory system and check for "free" or backup operation (10M) B
- o check any special equipment per manufacturer's recommendations B(as required)

Unit Total	15M +
------------	-------

GENERAL

- o record all changes in: timing, wiring, or any function AS REQUIRED
- o periodically check the electric bill for leaky insulation AS REQUIRED

2.4 PREVENTIVE MAINTENANCE DESCRIPTION BY ITEM

GENERAL

Each signalized intersection shall be inspected and preventive maintenance performed for the items and periods specified as outlined in the Preventive Maintenance Summary. This description provides general guidelines to aid the signal mechanic/technician in the performance of the individual task. The specific requirements unique to each manufacturer shall be followed for preventive maintenance.

Sophisticated test equipment and procedures can be time consuming and expensive and may not provide a realistic benefit cost ratio. The recommended "checks" and "inspections" in the following preventive maintenance description will permit the signal mechanic/technician to use visual and audio senses, experience, common sense and limited test equipment to evaluate the actual field condition.

The signal mechanic/technician shall be trained in the maintenance and protection of traffic as per the Manual on Uniform Traffic Control Devices and the Pennsylvania Department of Transportation's Bulletin 43 and Bulletin 90. Before any "on the street" checks or tests are performed, the signal mechanic/technician shall install all the applicable warning signs, channelization devices, etc. necessary to ensure safe operation of the intersection during preventive maintenance.

Each maintenance inspection shall be conducted by at least one signal mechanic. An inspection report shall be completed upon each inspection indicating the location, date, inspector's name, a list of all maintenance tasks performed and troubles found. Two copies of each inspection report shall be required, one kept at the intersection and the other stored in a central file.

MECHANICAL

CABINETS

Painting (only after the cabinet inspection items below are completed)

Each metal controller cabinet require periodic painting. First the cabinet shall be washed, using an industrial detergent solution. If, after washing, the condition of the cabinet paint is not chipped, peeled or faded, painting may be rescheduled for the next maintenance inspection.

Before applying paint, rust spots shall be cleaned using a wire brush. Steel cabinets shall be first painted with a protective primer such as zinc chromate or red lead. All coats, including the first coat of primer, shall be applied uniformly. Care shall be directed to avoid paint on gasket material, keyholes, hinge points and door jambs.

Oiling of Hinges and Locks

The hinge pins for cabinet doors, the linkages of three point (or two point) latching assemblies, equipment gates and locks require periodic oiling. Only the bare minimum of oil shall be applied. Any excess oil shall be removed.

Clean Filters

The air filters in cabinets shall be cleaned at the intervals indicated. A vacuum cleaner shall be used to remove the accumulated dust.

Replace Filter

The filter shall be replaced at the intervals indicated.

Weatherproof Seal (Gaskets)

All gaskets shall be examined for serviceability. The gasket around the door, the door-in-door, and all bolted-on devices such as registers shall be examined for

evidence of moisture. If a gasket is not mounted properly, it shall be reattached using a cement. The minimum amount of attaching cement shall be used, being careful not to soak the gasket. Faulty gaskets shall be replaced. Replacement gaskets shall be of a neoprene type material.

Anchor Bolts

The anchor nuts shall be inspected for tightness. If loose, nuts shall be retightened, keeping the cabinet level. Also, if there are signs of rust, the rust shall be removed using a wire brush, and the unprotected area coated with either zinc chromate or red lead.

Gas/Water Accumulation, Duct Seal

The inside bottom of the cabinet shall be inspected for evidence of water accumulation. If standing water or evidence of water damage are present, a check shall be made for dirt or plant growth around the outside of the cabinet that may be interfering with the drainage. Absence of weep holes or gaps between the cabinet and foundation which would provide drainage shall be checked. The conduit entering the cabinet through the foundation shall be sealed with duct sealant to prevent gas from entering the cabinet and shall not be used as a drain.

Ground Rod Clamp

The ground rod shall be checked using a 60 watt test lamp. All wires to the ground rod shall be disconnected. The shell lead of a 60 watt test lamp shall then be connected to the ground rod and the tip lead of the test lamp to the AC plus. If the lamp lights at full brilliance, the ground rod passes the test. If the lamp illuminates at less than full brilliance, the ground rod may be a poor ground. The above test shall be repeated for each ground rod. If one or more rods pass the test at a given location, all ground rods including those testing

poorly and the disconnected ground wires for that location shall be reconnected to the common ground conductor. If all ground rods at a location fail, a new ground rod may be installed or the soil treated, or both, and the test shall be repeated until there is a good ground.

Wiring Schematics

The signal mechanic shall check and indicate on the inspection sheet that the intersection controller cabinet has in its storage pouch a complete set of drawings for the intersection (i.e., wiring schematic, preventive maintenance record, intersection maintenance log sheet, master time sheet, and Pennsylvania Department of Transportation's permit drawing). The inspection sheet shall indicate the exact title of all missing drawings. Copies of the missing drawings shall be obtained and placed in the storage pouch.

Fan and Heater

The fan and heater shall be turned on for an operational check. If thermostatically controlled, the automatic operation shall be checked by manually operating one device to check the other.

SIGNAL HEADS

Paint Exterior of Signal (only after the signal inspection items below are completed)

All metal signal heads require periodic painting. Each signal head shall be first washed using an industrial detergent solution. If the condition of the paint after washing is not chipped, peeled, or faded, painting may be rescheduled for the next inspection. When painting signals, paint shall be kept off lenses, gaskets and door latches.

Cleaning Lenses and Signs

Each signal section shall be cleaned at the interval indicated in the summary. The lens and reflector shall be cleaned using a clean paper or cloth towel and an

approved cleaning agent. The inside shall be cleaned first, starting with the reflector, then the inside of the lens and finally the outside of the lens shall be cleaned.

LAMP REPLACEMENT

For group replacement all incandescent lamps shall be replaced after 12 months use. Only lamps having a 6000 hour rated life shall be used for replacement (6000 rating signifies that 50 percent of the lamps last that long). The lamp shall be installed properly, i.e., the filament opening in the "up" position. A separate maintenance schedule shall be required for non-incandescent signal indication light sources. Lamps for incandescent signals shall have a 3" light center length with 1750 lumens for 12" signal sections or a 2 7/16" light center length with 595 lumens for 8" signal sections.

ALIGNMENT

The signal faces shall be checked for proper alignment, both horizontal and vertical. Faces not properly aligned shall be inspected to determine the cause of misalignment. If locking parts are missing or were improperly assembled, they shall be installed or corrected as part of the realignment effort.

CHECK WEAR (SPAN)

The span wire hanger, clevis pins, signal cable and related hardware shall be checked during each inspection for possible wear. Parts showing wear shall be replaced. Attempts shall be made to determine the cause for the wear and to remedy the situation. The location having minor wear shall be noted on the inspection report. When the inspection is finished, the signal shall be vertically plumb and free to swing in a horizontal direction.

Signs shall be inspected for legibility, mounting and damage. The sign shall be cleaned with an approved detergent or replaced as required.

Check Wear (Mast Arm)

All mast arm mounted signals, particularly free-swinging signal hardware, shall be inspected for wear. Worn parts shall be replaced. If the wear is unusual or recurring, an attempt shall be made to prevent its recurrence. In some cases, redesign may be justified. When the inspection is finished, the signal shall be vertically plumb and free to swing in a horizontal direction.

Check for Cracks or Rust

The rust shall be cleaned and the area checked for cracks. All structures, brackets, signal faces, cabinets and covers shall be checked for cracks. The signal mechanic shall examine the base of poles and monotubes, as well as seams, corners, and threaded joints. Any part which appears to be failing shall be tested for adequate strength and replaced if necessary. For example, a pole may be tested for deflection resistance.

Hoods, Hinges and Wing Nuts

The bent hoods shall be replaced and returned for straightening at the signal shop. Signal face hinges shall be examined for wear or failure. Hinge pins shall be checked if secure in place. Integrally cast hinge lugs that are damaged shall require replacement of either the section or the door. Captive wing nuts shall require filing the threads of the eye bolt before they may be replaced.

Replacement Parts

Stainless steel, aluminum, or polycarbonate hardware shall be used to replace external signal parts. Electrical hardware shall be brass, bronze, copper, or silver.

Lenses and Reflectors

Replacement lenses shall be ultra-violet stabilized plastic or glass and shall conform to ITE standards for light distribution and color.

Reflectors shall be parabolic glass, alzac aluminum, or heat stabilized polycarbonate.

Locking Rings

All signal fixtures shall have integrally cast serrated openings and matching serrated brackets, or keyed serrated locking rings. If missing, locking devices shall be added as part of the maintenance.

Nighttime Check for Visibility

Each approach to the signal shall be checked at night for visibility of the indications and effects of background lighting (i.e., advertisement signs, street lights, etc.), and tree growth.

MAST ARMS AND POLES

Painting (only after the pole and mast arm inspection items below are completed)

Poles and mast arms fabricated from steel (except weathering steel) require periodic painting. All such structures (standards) shall be prepared for painting by first baring rust spots using a wire brush. The bare spots shall be primed with zinc chromate or red lead. The entire surface of the pole, mast arm and signal brackets shall then be painted.

Inspect for Rust and Spot Paint

All steel mast arms, signal brackets and pole shafts shall be inspected for rust. Rust spots shall be bared using a wire brush. The stripped metal surface shall be primed and painted, overlapping a small portion of the surrounding surface.

Inspect Joints

All seams and joints shall be inspected for cracks including cold welds, tears and metal fatigue. Particular attention shall be directed to the base of pole shafts and the base of mast arms. Any mast arm, bracket or pole having a joint failure or a seam failure shall be scheduled for a field re-weld or replacement.

Inspect Anchor Bolts for Tightness

If the anchor nuts and leveling nuts are loose, they shall be tightened. The pole shaft shall be plumb or raked as planned when the anchor and leveling nuts are tightened to the specified torque.

Inspect Anchor Bolts for Rust

The anchor bolts including the anchor and leveling nuts shall be inspected for rust. If the rust has noticeably reduced the diameter of the anchor bolt, it shall require a major repair. If anchor bolt couplers are used, the stud bolt shall be replaced. If anchor bolt couplers were not used originally, they may be installed on one or all of the anchor bolts, as a means for saving the pole foundation. To install the couplers, it may be necessary to remove some of the foundation around the damaged anchor bolt so that the anchor bolt may be threaded below ground line. Alternatively, a stud bolt may be welded to the undamaged portion of the anchor bolt below groundline. A new foundation may be installed if necessary.

Inspect the Horizontal and Vertical Angle of Mast Arms

The alignment of mast arms shall be checked. The cause of any misalignment shall be determined. If the misalignment was caused by a minor condition, the arm position shall be corrected. If the cause of misalignment is not minor, replacement of the faulty structure should be scheduled.

SPAN WIRE AND POLES

(Refer to the previous section for pole inspection)

Span or Tether Wire

The span wire shall be inspected for rust. The strands of span wire are usually galvanized or copper coated but after being in service, motion causes the galvanized or copper coating to eventually wear through. The strands of span wire are hard and resist rusting. However, badly corroded span wire shall be replaced. Pollution deposits on span wire shall not be mistaken for corrosion.

Clamps and Hardware

The clamps shall be checked for possible slippage. If a slip loop is present, the gap shall be measured periodically to determine if slippage has occurred. The original tension in the span shall be restored and clamps shall be retightened.

Guy Wire and Anchors

The anchors for back-guys shall be checked. The surrounding soil shall be stable and the back-guy in good condition. There shall be a guy-guard on the back-guy.

PUSH BUTTONS

Actuation, Visibility and Timing

The operation of each push button shall be checked using the actuated crosswalk to proceed to each push button station. A safe crossing period shall be ensured at the rate of four feet per second. A noticeably short timing shall be reported.

Push Button Indicator

If the push button includes an indicator (displaying "Please Wait"), a check for proper functioning of the indicator shall be made. The push button indicator lamps shall be group replaced.

Push Button Sign

The push button signs shall be inspected for legibility, mounting and damage. The push button sign shall be cleaned with an approved detergent or replaced as required.

Sign Alignment

The push button sign shall be mounted in such a way that pedestrian traffic may understand without confusion which crosswalk the push button controls. If confusing, signs shall be relocated as per the standard detail.

DETECTOR SENSORS

Loop Type

The roadway condition at and around the buried detector loop shall be visually checked. Pot holes shall be reported immediately and repaired as soon as possible. The sealant along the surface of the buried loop and lead-in shall be examined and replaced as required.

Sonic, Radar and Magnetic Types

All three detector types shall be checked and repositioned if required to confirm that their zone of detection has not shifted due to movement of the detector transducer. The operation at the central unit shall be checked and sensitivity shall be reset if necessary.

Pressure Detector

The roadway conditions shall be checked for deterioration around each pressure detector especially near the frame. If replacement is necessary, a different type

detector may be considered unless special traffic operation conditions can be met only by use of a pressure detector. The operation shall be checked.

UNDERGROUND

JUNCTION BOX AND HANDHOLES OF TRAFFIC STANDARDS

Check Integrity of Splicing

The underground splices shall be visually inspected for deterioration and/or damage. If a splice appears to warrant further inspection, the monthly electric bill shall be checked for normal electrical consumption. Resplicing may be necessary if energy consumption is higher than normal.

Check Ground Rod and Clamp Connection and Bonding

The grounding circuit shall be checked if it is secure and functional. A test lamp may be used to check the connections between structures, conduit and the ground rod for continuity.

Check the Insulation

The insulation and/or cable jackets shall be checked if rubbing on hard or sharp surfaces. If it appears that only the wiring insulation has been damaged, the insulation shall be restored with tape. Strain relief may be installed for the condition not to reoccur. The repair shall be waterproof.

Check for Abnormal Amounts of Water

The bottom of junction boxes, inside of pole shafts and controller cabinets shall be checked for water or water damage. If water or evidence of water is found it shall be ensured that there are weep holes and drainage, and that draining is not blocked by waterborne sediment.

Check Lid for Abnormal Condition and Fit

The lids of junction boxes shall be checked to be flush and of the correct size. The lid shall keep foreign material out of the junction box, and at the same time fit so that pedestrian traffic will not trip over it.

ELECTRICAL

Radio Interference

The controller and flasher motors shall be checked for radio interference, by connecting a radio to the same power source and moving the dial off station. If interference is then noted, the filter and choke coil shall be replaced. This noise is carried by the electric lines to any radio or TV set on the transformer or through air waves to those in the immediate area.

ELECTROMECHANICAL CONTROL EQUIPMENT

DIAL ASSEMBLY

Check for Wear on Key Follower

Excessive wear on the contact block follower shall be checked. All of the dial keys functioning on each follower shall be checked for rough edges. Any such keys shall be replaced. If the defective key cannot be easily corrected, it shall be discarded.

Check for Burning or Pitted Contacts and Correct

The dial unit's contact block shall be adjusted for cleaning action due to the correct amount of over-travel. The pitted contacts may be cleaned using a contact file, making sure only the silver oxide is removed.

Check for Key Positions

The dial key positions shall be checked for correct interval timing.

Cycle Gear and Mesh

The correct size cycle gear shall be checked in each dial unit. There will be a small amount of gear backlash when the cycle gear is installed correctly.

Check Dial Motor Operation

The dial drive motor operation shall be checked. The motor shall run warm but not hot. The dial driving motor shall operate quietly; noisy motors shall be replaced. Because of the backlash, the dial may not turn smoothly, but may dwell momentarily as each key passes the switch block.

Check All Dials According to Manufacturer's Recommendations

The specific requirements unique to each manufacturer shall be followed for preventive maintenance.

If Controller is Part of a System, Check Offset

If the controller's offset function is connected to a remote master unit, or a local time based unit, it shall be checked for proper operation. The called offset may be checked by turning the dial motor off for approximately five seconds. The dial unit thereafter and until it is back in step with the synchronous function shall stop each time the offset key crosses the stack switches. If re-synchronization interruption is present, the dial stopping period shall be time limited. Thus, if the total time needed to synchronize the dial is excessive, re-synchronizing may be distributed over several cycles. It may not be easy to confirm the operation of all offsets for all dials. If the first selected offset checks out properly, verification for the other offsets may not be warranted. However, a different offset shall be checked by scheduling the next inspection at a different time-of-day.

CAM ASSEMBLY

Check Duration of Advance Pulse

The duration of each advance is dependent upon two factors, the cycle time and the dial unit switch block position. Whenever a dial unit is changed to a longer or a shorter cycle, the advance duration shall be checked. The average duration for most pretimed controllers is 500 milliseconds (1/2 second). Most controllers function dependably well if the duration is anywhere between 300 and 900 milliseconds. For example, some controllers have been tested for dependable operation with an advance duration as short as 100 milliseconds. However, if the line voltage is 95 volts, the temperature below freezing, and with a full complement of signal circuits, at least 300 milliseconds advance duration is necessary, and 500 milliseconds should provide a comfortable margin of safety. Durations greater than one second are too long for a device designed for pulsed operation. The dial unit switch block may be raised or lowered to adjust the advance duration.

Check for End Play

The camshaft shall be checked for end play. The amount of end play shall be limited, and must be within manufacturer's recommendations. If information is not available, 1/32 inch may allow correct functioning for most pretimed traffic signal controllers. However, adjustments shall not be made if the controller is functioning properly.

Clean and Lubricate as Required by Manufacturer

Most pretimed controllers are lubricated for life. Both the dial unit and camshaft usually have pre-oiled bearings. However, some older controllers still in service may require periodic oiling. If the manufacturer's recommendations are no longer available, usually a few drops of light-weight machine oil on each bearing once a year shall suffice.

Visually Inspect for Abnormal Wear and/or Cracks

The controller shall be inspected for wear and/or cracks. Wear may be indicated if there is transverse play at bearing points. Cracks may be found in castings and on flat metal parts near bends and holes. Controllers having any of the above conditions shall be replaced and serviced as required.

Visually Inspect Contacts

The burned and pitted contacts shall be cleaned, or if severely burned shall be replaced. Cleaning shall be done using a relay contact file, making sure only the silver oxide is removed, not the silver.

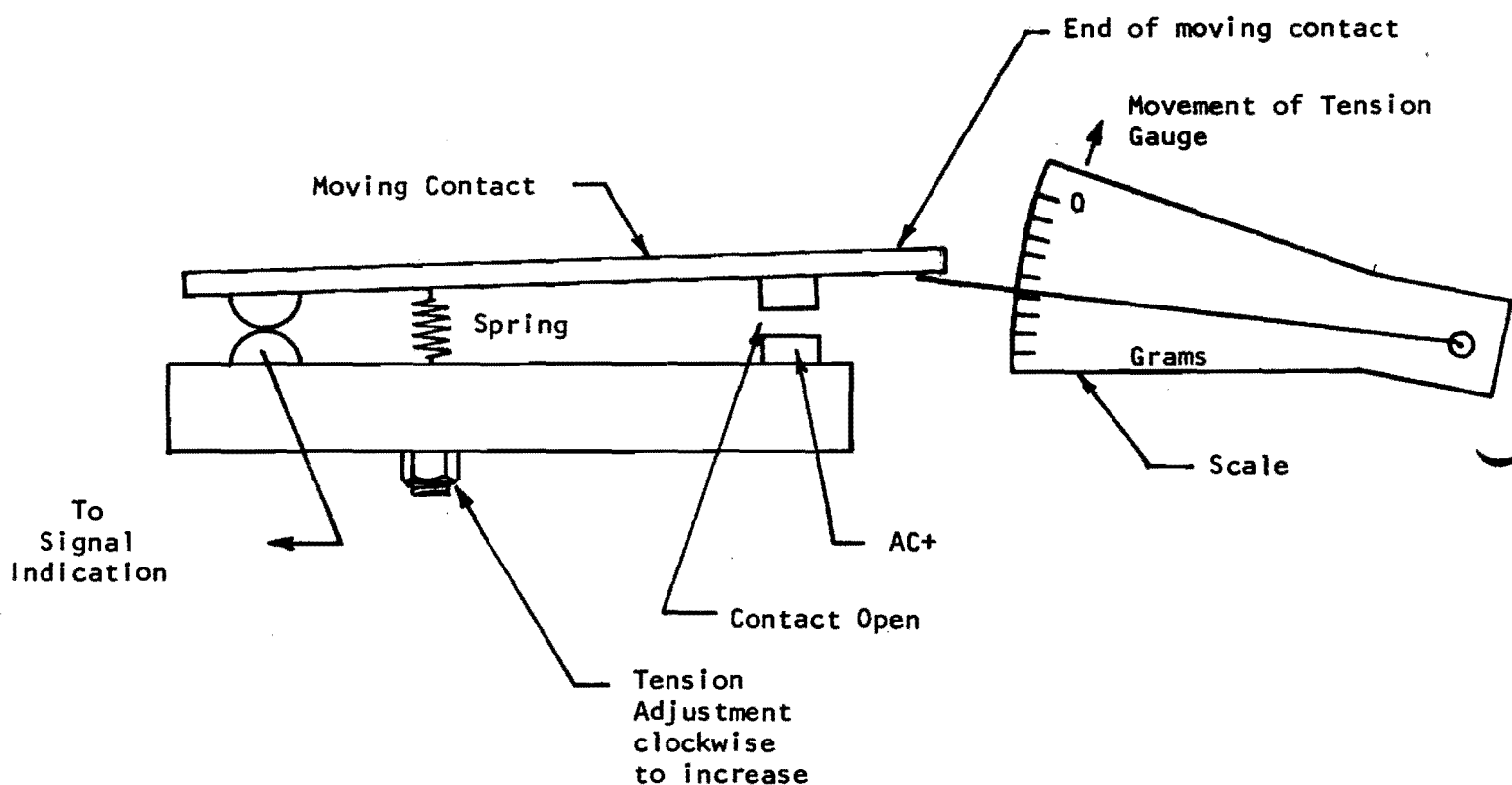
Check Spring Tension on Contacts

The necessary spring tension for each pretimed traffic signal controller shall be set to manufacturer's recommendations whenever a full complement of signal circuits are required. The maximum tension may be set only if there are a minimum of signal circuits used, otherwise a medium tension shall be set.

The tension may be checked using a tension gauge. (See Figure 2-2.) With the controller in the flashing mode, the camshaft shall be advanced manually until the test contact is "ON". The contact shall be opened by pressing the tension gauge against the end of the moving arm and the gauge pointer read. Any contacts that have low tension shall be tightened to the manufacturer's specifications. Likewise, if the camshaft appears to be binding due to the tension of the signal circuits, the pressure on the contacts having the greatest tension may be reduced. No contact tension shall be less than minimum.

Check Loose Wiring to Contacts

The connections to the signal circuit switches shall be checked for tightness. Any discoloration at the lead-in wire lug may indicate a loose connection. A

SPRING TENSION GAUGE

- Read gauge scale before measuring, it may not be zero.
- Open contact by pressing gauge pointer against end of moving contact.
- Stop when contact opens and Read gauge scale.
- Difference of gauge readings is contact pressure.

slight hand pressure applied to each wire shall confirm tightness. A gentle clockwise twist, using an electrician's screwdriver on each screw, may also confirm tightness. The correct size screwdriver shall be placed squarely in the screwhead slot so that the screwhead is not damaged by this test.

Check for Operation of Advancing Mechanism to Conform with Manufacturer's Requirements

The advancing mechanism travel is set for the number of camshaft positions. For ratchet type camshaft drives, travel shall be checked to allow the pawl to engage into the next tooth of the ratchet wheel. For direct drive types, the camshaft indexing contact shall be checked for opening when the camshaft is in the center of the interval.

Check if all Connections are Secure and Tight

The connector plug and socket sets shall mate firmly for good electric contact. The controller chassis or tray connections shall be checked for integrity. Any connection which appears to be cold soldered, or mechanically failing shall be resoldered or replaced.

Visually Inspect Wires for Wear, Rubbing or Deterioration of Insulation

The wire harnesses shall fit loosely but secure and not rub on sharp edges. Strain relief material and any additional protection shall be provided to protect wires from damage during normal operation.

Install Dust Cover as Required

The dust cover protects the equipment from airborne pollution, when properly installed. The signal mechanic shall reinstall the dust cover when his inspection is finished.

RELAYS

Check Contacts

The burned and pitted relay contacts shall be cleaned or replaced. Cleaning shall be done using a relay contact file, making sure only the silver oxide is removed, not the silver.

Check for Tight and Secure Fit into the Socket

The dial transfer relays of the mechanical latching type and some electrical latching types usually mount with banana jacks. Sometimes minor variations in the layout of the jacks cause angular movement and eventual loosening of the individual jacks. Also, careless plugging and unplugging add to the looseness. The relay mounting assembly shall be checked and damaged jacks replaced. All relays shall be firmly mounted in place.

If Mechanical Latch-Type Relays, Check for Latch Operation as per Manufacturer's Recommendation

The latching operation of dial transfer relays activates once each cycle. A 60 second cycle installation requires the relay to operate over 500,000 times each year. If dial transfer is not required, the dial transfer relays shall be removed and jumpers installed as a preventive maintenance effort.

When dial transfer is used, latching relays will have a life expectancy of approximately five years.

FLASHERS

Check Flasher Rate

The flasher rate shall be approximately one ON/OFF pulse per second. The rate shall produce between 57 to 63 pulses per minute. For some flashers the rate is

adjustable. The flasher shall be replaced if the rate is not correct and cannot be field adjusted.

Check Operation

The flasher duration shall provide equal ON and OFF states. Some electro-mechanical flashers have fanned cams for adjusting the ON and OFF durations. The flasher shall be replaced if the duration is not correct and cannot be field adjusted.

Service Contacts as per Manufacturer's Recommendation

The heavy silver flasher contacts shall be cleaned using a relay contact file, making sure only silver oxide is removed, not silver. The badly pitted flasher contacts shall be replaced.

Check for Tight and Secure Fit into Sockets

The flasher shall be checked if securely mounted into the panel socket.

SWITCHES

Verify Operation of Each Switch Position

The switch shall be thrown to each position, including the OFF position, and the controller operation shall be verified.

TERMINAL CONNECTIONS

Check Visually for Signs of Corrosion or any Abnormal Condition

All terminal strips shall be checked for discoloration, darkening of the copper surfaces, and any light colored deposit on the plastic surface. Any deposits shall be removed with an approved cleaning agent.

Tighten all Terminal Connections

Each screw terminal shall be tested to confirm its tightness, using an insulated screwdriver. The correct size screwdriver shall be used to ensure that the screwheads are not damaged by this testing.

CONFLICT MONITOR

(Refer to Solid State Section)

DETECTOR AMPLIFIER

(Refer to Solid State Section)

ANALOG CONTROLLERS

Check if the Time Settings Match the Master Time Sheet.

Use a stop-watch, with the master timing sheet to check the timing. If the timing agrees, or if made to agree by re-positioning the potentiometer control, it may be necessary to calibrate the central pointer to the marked scale. Calibration may be accomplished by loosening the knob, re-positioning the pointer to indicate the correct setting, and re-tightening the knob.

If the analog controller has recently required tube replacement, or other component replacement, it may need re-calibration, beyond that of re-positioning knob pointers.

The brush on potentiometer timing controls may be cleaned by turning the control briskly through 90 degrees or more and back. Turn the control to the increasing direction so the interval is not shortened.

SOLID STATE AND MICROPROCESSOR BASED CONTROL EQUIPMENT

Check if the Time Settings Match the Master Time Sheet

The time settings on the controller shall be checked and readjusted to conform with the master time sheet as prepared by the traffic engineer and enclosed in the controller cabinet pouch.

Check Indicator Lamps

All indicator lamps shall be checked and replaced if burned out.

Check for Extension by Detector Actuation

The inspector shall observe the detector actuation indicator, and make sure that a full Passage Time period times, keeping in mind that the period may be terminated by a Force-off or a timed out Maximum Green.

Check if the Modules are Fitting Tight and Secure into the Frame

The circuit board modules shall be checked to be fully engaged into the mother board edge connectors.

Check if the Connectors are Tight and Secure

All connectors shall be checked if tight and secure. The MS type connectors require tightening the threaded/knurled locking ring until the mating connections are fully engaged.

DETECTOR AMPLIFIER

(Refer to Solid State Section)

LOAD SWITCHES

The load switch packs shall be checked if fitting tight and secure into the chassis. All three circuits shall be checked (two if pedestrian signal) if functioning properly and replaced if necessary.

CONFLICT MONITOR

Check Conflict Monitor and Stop Timing

The green signal circuits of two conflicting phases (one must be ON) shall be

connected using a short insulated wire to check if the Conflict Monitor responds, i.e., the operation goes into flash and the stop timing is implemented. The above procedure shall be repeated for conflicting signals: Yellow/Green, Green/Walk, Walk/Yellow, plus any other Green/Green combinations. The test shall be repeated for any red signal circuits being monitored, disconnecting one red circuit at a time. The 24 volt DC input to the monitor shall be disconnected to check if operation goes into flash.

FLASHERS

(Refer to Electromechanical Section)

SWITCHES

(Refer to Electromechanical Section)

TERMINAL CONNECTIONS

(Refer to Electromechanical Section)

RELAYS

(Refer to Electromechanical Section)

AUXILIARY LOGIC

The points of contact (i.e., edge connector, DIP sockets, ribbon connector, etc.) shall be checked for tight fit and good contact. If electromechanical (i.e., relays, timers, etc.), check shall be made for wear (i.e., discoloration of nearby surfaces etc.). If cleaning is required, manufacturer's recommendations shall be followed. If no data is available, contacts shall be cleaned with contact file, making sure only silver oxide is removed. Contacts shall be at least 50 percent of original size after cleaning.

DETECTOR AMPLIFIER

Verify Detector Operation

The detection zone may be made easier to see by marking the pavement using yellow lumber crayon. The detection zone for each detector shall be verified by

observing the turn-on of the detector amplifier indicator as a vehicle passes over it.

Tuning

If necessary, the detector amplifier shall be retuned as per procedures outlined in the manufacturer's manual.

Check Connectors

The connector shall be checked for tightness before the inspection is completed.

INTERCONNECT EQUIPMENT

Controller Operation

The controller shall be checked if functioning in the mode selected by the supervisory master and local mode switches.

Check for Free or Backup Operation

The input to the interconnect equipment shall be disconnected to check if the intersection control returns to the backup mode. Defective equipment shall be repaired or replaced and the input reconnected.

Check Special Equipment

All tests recommended by the manufacturer shall be performed at the specified intervals. In all cases the equipment shall function properly when the inspection is completed.

MISCELLANEOUS

All changes in timing, wiring, or any functions shall be recorded.

Any unusual observations shall be reported.

2.5 **LIST OF EQUIPMENT REQUIREMENTS**
AND ESTIMATED PRICE FOR REPLACEMENT

General Notes

- NOTE 1.** The percent (%) quantities shown in the columns are the percentage of the total number of the item in the "Equipment" column, unless indicated otherwise.
- NOTE 2.** The quantities recommended shall be maintained for each non-interchangeable item in use.
Example: Lenses 2 or 5%: implies 2 or 5% of each non-interchangeable in use.
- NOTE 3.** The maximum of the two quantities listed shall be used.
Example: Signal Lenses - 2 or 5%. A municipality has 5 intersections. Each intersection has 4-3 section signal heads i.e. a total of 20 identical signal lenses of each red, green and yellow.
- 5% of 20 = 1
- However, the minimum number of spare lenses recommended is 2 of each color and this shall govern.
- NOTE 4.** The quantities recommended are the minimum and shall be replenished immediately to maintain these levels.
- NOTE 5.** "Same" in Level II or Level III implies the quantities recommended for these levels are the same quantities recommended for Level I.
- NOTE 6.** "As required" is used for various minor items necessary for preventive maintenance that shall be maintained in inventory.
- NOTE 7.** "If required" is used for items with a very low expected rate of failure and therefore do not warrant inventory.
- NOTE 8.** The quantities followed by (A) are required for level A preventive maintenance only.

General Notes Cont'd.

- NOTE 9:** Prices shown in the columns are for 1 unit unless otherwise noted (i.e. gallons, pounds, etc.) and do not included shipping and tax where applicable.
- NOTE 10:** Prices shown are average prices and will vary from one manufacturer to another manufacturer and between different models of the same manufacturer.
- NOTE 11:** Prices shown are not for special order or absolute equipment.
- NOTE 12:** All prices have been rounded up to the largest whole dollar.
- NOTE 13:** Volume purchases will reduce prices.

LIST OF EQUIPMENT REQUIREMENTS

<u>Equipment</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>1981 Average Price Per Unit</u>
Bucket Truck	For all 3 levels of maintenance: 1 or 3% of signalized intersections. If more than one truck is required the following purchase pattern is recommended: 1. Bucket truck 2. Platform truck 3. Ladder truck 4. Bucket truck 5. Ladder truck			\$ 35,000
Platform Truck				20,000
Ladder Truck				15,000
Multimeter		1 per person	same	100
Oscilloscope		1 per signal specialist	--	1,200
Controller Test Fixture (Bench Test)	1 or 2% of signalized intersections	same	same	2,000
Suitcase Tester	1 per signal specialist	--	--	2,000
Detector Sensor Test Equipment	1 per signal mechanic	same	same	600
Detector Test Fixture	1 per signal technician	same	--	500
Frequency Generator	1 per signal specialist	--	--	500
Frequency Counter	1 per signal specialist	--	--	800
Variac	1 per controller test fixture	same	same	100
Spring Tension Gauge	1 per signal mechanic	same	same	20
Small Tools	1 set per person	same	same	1,000
Vacuum Cleaner	1 per signal mechanic	same	--	100
Hardware Miscellaneous (such as electrical tape, wire, level, test lamp)	as required	same	same	100
Paint Miscellaneous (such as wire brushes, paint brushes)	1 set per signal mechanic	same	same	25

<u>Equipment</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>1981 Average Price Per Unit</u>
<u>MECHANICAL</u>				
<u>CABINET</u>				
Cabinet (shell)	1 or 2%	same	--	\$400-1,000
Primer	1 gal. or 2 gal. per 5 cabinets (A)	same	same	20-/gal.
Paint	1 gal. or 2 gal. per 5 cabinets (A)	same	same	20/gal.
Oil	1 pint or 1 gal. per (A) 100 cabinets	same	same	5/gal.
Filter	1 or 1% *	same	same	1
Gasket	10' or 1%	same	same	1/ft.
Anchor Bolt	4 or 8% (A)	same	--	10 each
Duct Sealant	5 lb. or 5 lb. per 20 controllers	same	same	5/5 lbs.
Grounding Clamp	1 or 1%	same	same	1
Fan	2 or 5%	same	same	25
Heater	2 or 5%	same	same	10
Thermostat	2 or 5%	same	same	3
Lock and Keys	2 or 5% (A)	same	same	8
Miscellaneous Hardware (Brass and Stainless Steel)	as required	same	same	100
<u>SIGNAL HEAD (PEDESTRIAN AND VEHICLE)</u>				
Lamp	2 or 5% *	same	same	3
Lens	2 or 5%	same	same	\$ 9-8" \$ 22-12"

* NOTE: 100% of these items will be required annually for group replacement.

<u>Equipment</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>1981 Average Price Per Unit</u>
Visor	2 or 5%	same	same	\$ 7-8" 12-12"
Reflector	2 or 5%	same	same	7-8" 12-12"
Lamp Socket	2 or 5%	same	same	3 180-8"
Signal	2 or 5%	same	same	250-12"
Signal Mounting Hardware	2 or 5%	same	same	75
Regulatory Sign	2 or 5%	same	same	50
Signal Cable	500 ft. of 5 conductor, AWG12	same	same	.25
Primer	1 gal. or 1 gal. per (A) 5 signal heads	same	same	20/gal.
Paint	1 gal. or 1 gal. per (A) 5 signal heads	same	same	20/gal.

MAST ARMS, POLES AND SPAN WIRE POLES

Primer	1 gal. or 5 gal. per pole (A)	same	same	20/gal.
Paint	1 gal. or 5 gal. per pole (A)	same	same	20/gal.
Mast Arm	1 or 5%	same	--	750
Pole Shaft or Pedestal	1 or 5%	same	--	750
Anchor Bolt	4 or 8% (A)	same	--	25/each
Handhole Cover	1 or 2% (A)	same	same	10
Grout	100 lb. or 100 lb. bag per 100 foundations	same	--	10/100 lb.
Miscellaneous Hardware	as required	same	same	25

SPAN WIRE

Messenger Cable Tensioner (come along)	1 per signal mechanic	same	same	100
Cable Clamp	2 or 5%	same	same	5

<u>Equipment</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>1981 Average Price Per Unit</u>
Anchor Bolt	4 or 8% (A)	same	--	\$ 25/each
Span Wire	1000 ft. or 1000 ft. per 100 spans	same	--	2
Tether Wire	1000 ft. or 1000 ft. per 100 spans	same	---	1
Miscellaneous Hardware	as required	same	same	25
<u>PUSH BUTTONS</u>				
Push Button Assembly	2 or 5%	same	same	35
Lamp and Lens	2 or 5%	same	same	5
Sign	1 or 2%	same	same	50
Push Button Post	2 or 5%	same	--	\$ 100-400
Miscellaneous Hardware	as required	same	same	25
<u>DETECTOR SENSORS</u>				
Re-enterable Splice Kit	1 or 1% (A)	same	--	46
Fluid for Re-enterable Splice Kit	2 pouches (21 oz ea.) or 5% of splices (A)	same	---	14/21 oz.
Sealant	1 gal. or 1 gal. per 25 ft. of sawcut	same	same	45/gal.
Sensor	2 or 5%	same	same	200
Pressure Pad	4 or 5%	same	same	400
Loop Wire	500 ft.	same	same	.16/ft.
Homerun Cable	1,000 ft.	same	same	1.00/ft.

<u>Equipment</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>1981 Average Price Per Unit</u>
<u>UNDERGROUND</u>				
<u>JUNCTION BOXES AND HANDHOLES</u>				
Spare Handhole Cover	1 or 2% (A)	same	same	\$ 10
Junction Box Cover	1 or 1%	same	same	75
Miscellaneous Hardware	as required	same	same	5
<u>ELECTRICAL</u>				
Radio Interference Filters	1 or 2%	same	same	25
<u>ELECTROMECHANICAL CONTROLLER</u>				
Dust Cover	1 or 2%	--	--	15
Controller	1 or 2%	same	same	
<u>DIAL ASSEMBLY</u>				
Dial Unit	2 or 5%	same	same	180
Cycle Gear	2 or 5%	same	same	3
Key	2 or 5%	same	same	1
Motor	2 or 5%	same	same	50
Contacts	5 or 10%	same	same	3
Synchronizing Relay	2 or 5%	same	same	8
Amphenol Socket	1 or 2%	same	same	1
Miscellaneous Hardware	as required	same	same	25

<u>Equipment</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>1981 Average Price Per Unit</u>
<u>CAM ASSEMBLY</u>				
Cam	5 or 5%	same	same	\$ 1
Advancing Mechanism	2 or 5%	same	same	70
Ratchet and Pawl	2 or 5%	same	same	15
Contacts and Spring	5 or 10%	same	same	6
Shaft Bearing	if required	same	same	1
Oil	1 pint or 1 gal. per 100 controllers	same	same	5/gal.
Relay (Crouse-Hinds type)	10 or 20%	same	same	54
<u>RELAYS</u>				
Dial Transfer Relay	2 or 5%	same	same	110
Flash Relay	2 or 5%	same	same	70
Contacts	5 or 10%	same	same	5
Relay Connector	4 or 8%	same	same	1
<u>FLASHERS</u>				
Flasher Unit	1 or 3%	2 or 5%	2 or 5%	90
Contacts and Motor for Mechanical Type Flasher	5 or 10%	same	same	20
Flasher Connector	4 or 8%	same	same	1
Components	as required	--	--	25

<u>Equipment</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>1981 Average Price Per Unit</u>
<u>SWITCHES</u>				
Switch	1 or 1%	same	same	\$ 3
Time Switch	2 or 5%	same	same	80
<u>CONFLICT MONITOR</u>				5 Channels \$ 500
Conflict Monitor	1 or 3%	2 or 5%	2 or 5%	12 Channels \$ 800
Components as Listed by Manufacturer	as required	--	--	\$ 25
<u>DETECTOR AMPLIFIER</u>				
Detector Amplifier	2 or 10%	2 or 20%	2 or 20%	180/Channel
Power Supply for Amplifier	2 or 5%	2 or 10%	--	176
Components	as required	--	--	25
<u>ANALOG CONTROLLERS</u>				
Potentiometers	2 or 5%	2 or 5%	2 or 5%	3
Indicators	2 or 5%	2 or 5%	2 or 5%	1
Load Relays	2 or 10%	2 or 10%	2 or 10%	120
Miscellaneous Components	as required	--	--	25
Controller	1 or 2%	1 or 5%	1 or 10%	2,000
<u>SOLID STATE AND MICROPROCESSOR BASED CONTROLLERS</u>				
Load Switch	3 or 5%	same	same	100
Power Supply for Load Switches	2 or 2%	same	--	120

<u>Equipment</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>1981 Average Price Per Unit</u>
Load Switch Components	as required	--	--	\$ 25
Solid State Replacement Relay for Load Switcher	3 or 30% of load switches	same	--	35
Controller	1 or 5%	same	same	See page 2-48
Module and Board	3 or 5%	same	--	See page 2-48
Power Supply for Controller	2 or 5%	same	--	See page 2-48
Other Components as Recommended by Manufacturer	as required	--	--	200
<u>AUXILIARY LOGIC</u>				
Backup Components per Logic Card (preemptor)	as required	--	--	100
<u>INTERCONNECT EQUIPMENT</u>				
Backup Master	--	--	--	--
Interface Unit	1 or 5%	2 or 10%	2 or 10%	1,000
Dial Unit (synchrolizer)	3 or 5%	1 or 5%	1 or 5%	250
Coordination Unit	1 or 5%	1 or 5%	1 or 10%	370
Miscellaneous Components	as required	--	--	50

2.5 CONTINUED

ESTIMATED 1981 PRICE LIST FOR REPLACEMENT OF A

SOLID STATE CONTROLLER TIMER

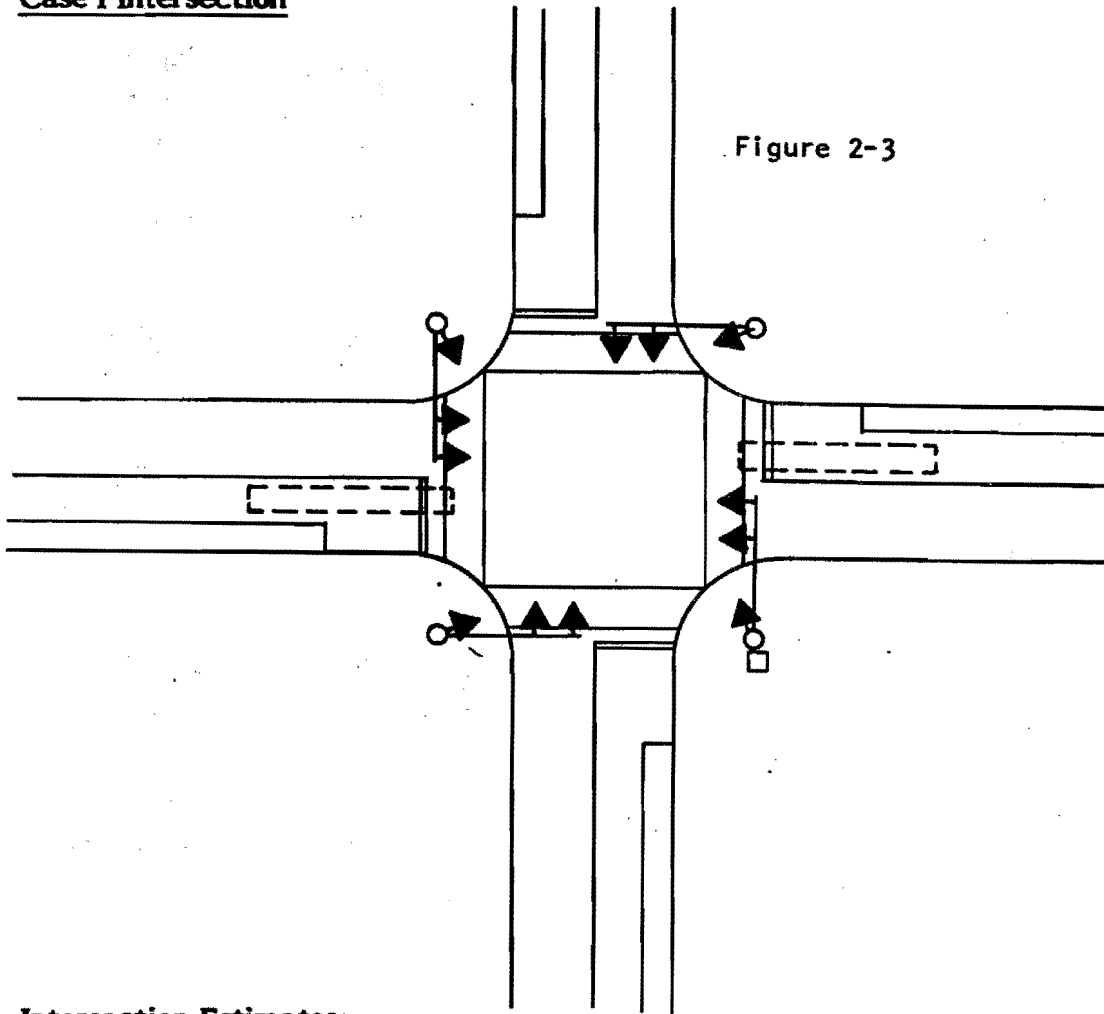
WITH EXPANSIBLE FRAME

<u>Number of Phases</u>	<u>Controller Chassis*</u>	<u>Phase Module</u>	<u>Total Cost</u>
2	\$3,100	\$ 400	\$3,500
3	3,100	600	3,700
4	3,100	800	3,900
5	3,100	1,000	4,100
6	3,100	1,200	4,300
7	3,100	1,400	4,500
8	3,100	1,600	4,700

*Includes mainframe, power supply, overlap modules, miscellaneous timers, etc.

2.6 ESTIMATED MANPOWER REQUIREMENTS
TO PERFORM ANNUAL PREVENTIVE
MAINTENANCE FOR TYPICAL INTERSECTIONS

Case I Intersection



Intersection Estimates:

1. 4 approaches
2. 12 signal heads
3. 4 mast arms and standards
4. no pedestrian signals
5. 4 pedestrian push buttons
6. 2 loop detectors
7. 4 junction boxes and hand holes
8. semi-actuated electromechanical controller

**Case I Intersection - Time Calculations Based On
Time Estimates for Preventive Maintenance**

	<u>Months</u>			<u>Years</u>
	<u>3</u>	<u>6</u>	<u>12</u>	<u>2-5</u>
Cabinet	—	0:05	0:14	3:00
Signal Heads (12)	—	5:24	2:24	12:00
Nighttime Check (4 Approaches)	—	0:40	—	—
Mast Arm and Poles (4)	—	—	1:20	32:00
Pedestrian Push Buttons (4)	—	1:00	—	—
Junction Boxes and Handholes (4)	—	—	0:40	—
Detector (2 Approaches)				
o loop inspection	0:10	—	—	—
o detector amplifier (2)	0:40	—	—	—
Controller (Electromechanical)	—	—	8:00	—
	0:50	7:09	12:38	47:00
Travel Time*	1:00	1:00	2:00	—
	1:50	8:09	14:38	47:00**

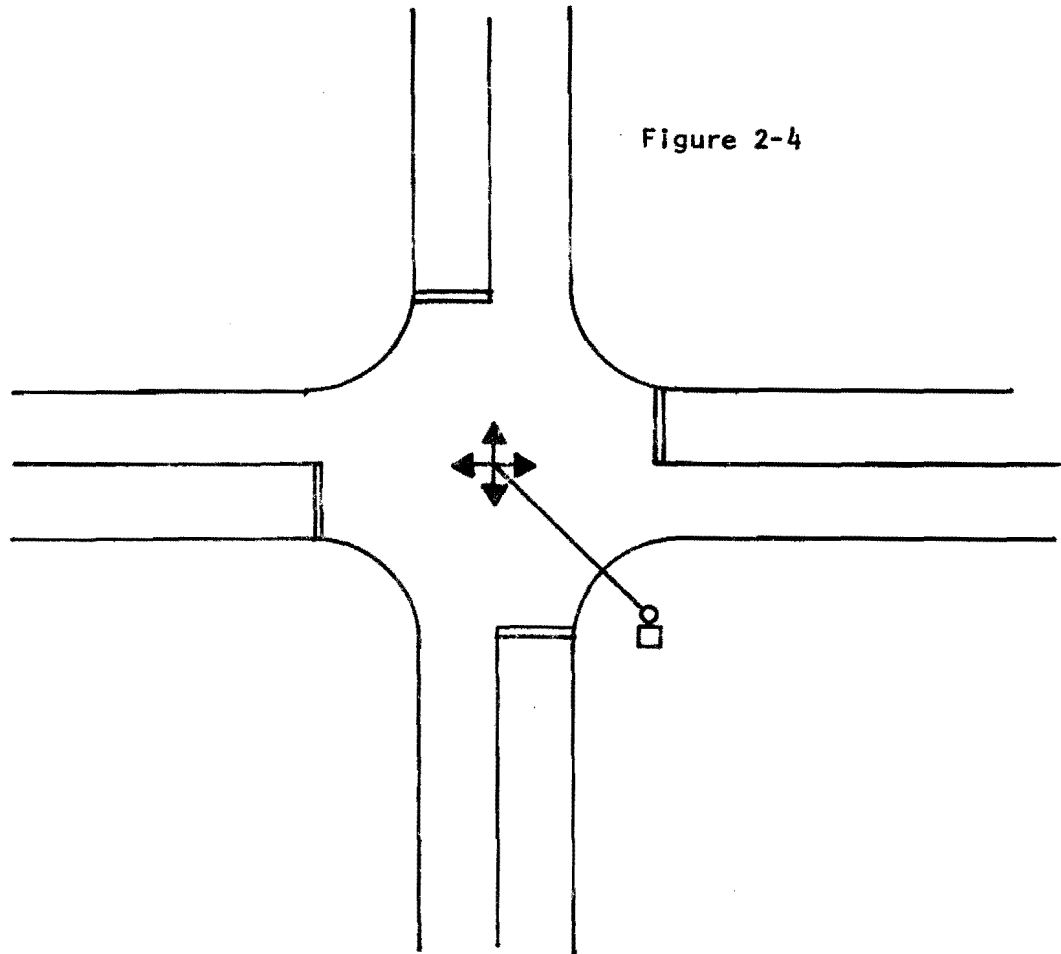
Therefore, per year: $(1:50) \times 4 + (8:09) \times 2 + 14:38$
= 38:16 hours

Record Keeping per year 2 hours

Total hours for
Preventive Maintenance
per year per intersection: 41 hours

*1 hour per 6.5 hours of working time
**2-5 year maintenance time is not included in the
yearly time estimates.

Case II Intersection



Intersection Estimates:

1. 4 approaches
2. 4 signal heads
3. 1 mast arm and standard
4. no pedestrian signals
5. no pedestrian push buttons
6. no detectors
7. 1 junction box and hand hole
8. electromechanical controller

**Case II Intersection - Calculations Based on
Time Estimates for Preventive Maintenance**

	<u>Months</u>			<u>Years</u>
	<u>3</u>	<u>6</u>	<u>12</u>	<u>2-5</u>
Cabinet	—	0:05	0:14	3:00
Signal Heads (4)	—	1:48	0:48	4:00
Nighttime Check (4 Approaches)	—	0:40	—	—
Mast Arm and Poles (1)	—	—	0:20	8:00
Junction Boxes and Handholes (1)	—	—	0:10	—
Controller (Electromechanical)	—	—	<u>8:00</u>	—
	—	2:33	9:32	15:00
Travel Time*	—	<u>1:00</u>	<u>2:00</u>	—
	—	2:33	11:32	15:00**

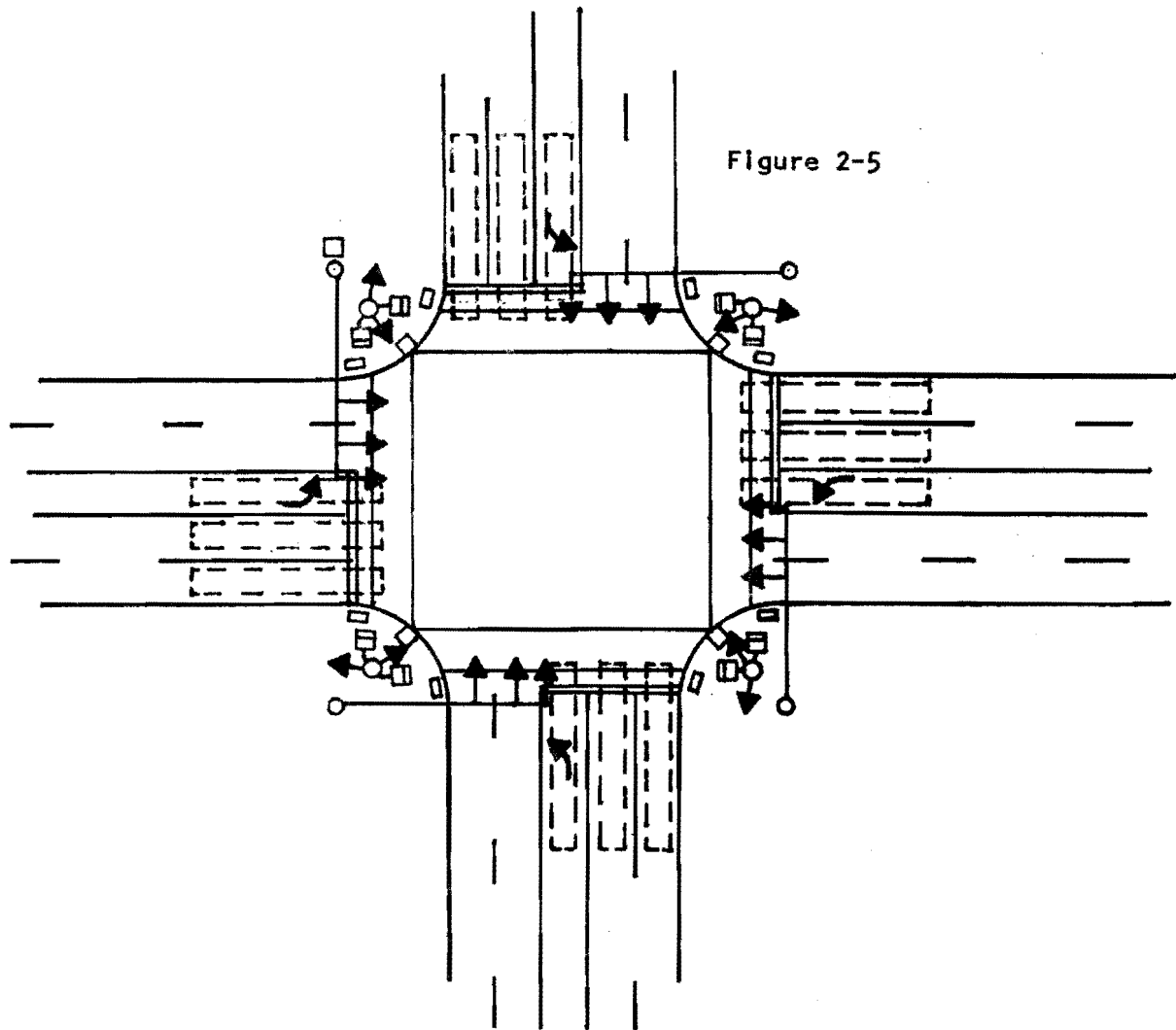
Therefore, per year: $(2:33) \times 2 + 11:32$
 = 16:38

Record Keeping per year 1.5 hours

Total hours for
Preventive Maintenance
per year per
intersection: 18 hours

- *1 hour per each 6.5 hours of working time
 **2-5 years maintenance time is not included in the
 yearly time estimates.

Case III Intersection



Intersection Estimates:

1. 4 approaches
2. 20 signal heads
3. 4 mast arms and standards
4. 4 traffic standards for pedestrian signals and push buttons
5. 8 pedestrian signals
6. 8 pedestrian push buttons
7. 12 loop detectors, 3 per approach
8. 8 junction boxes and hand holes
9. solid state volume density controller

**Case III Intersection - Time Calculations Based On
Time Estimates for Preventive Maintenance**

	<u>Months</u>			<u>Years</u>
	<u>3</u>	<u>6</u>	<u>12</u>	<u>2-5</u>
Cabinet (1)	--	0:05	0:14	3:00
Signal Heads (28, including pedestrian)	--	12:36	5:36	28:00
Nighttime Check (4 Approaches)	--	0:40	--	--
Mast Arms and Poles (8, including pedestrian)	--	--	2:40	64:00
Pedestrian Push Buttons (8)	--	1:00	--	--
Detector (4 approaches)				
o loop inspection	1:00	--	--	--
o amplifiers (4) 2 channels/unit	2:40	--	--	--
Junction Boxes and Handholes (8)	--	--	1:20	--
Controller: (Solid State)	--	0:05	0:20	--
Load Switches	--	--	0:05	--
Conflict Monitor	--	--	0:10	--
Flasher	--	--	0:05	--
Switches	--	--	0:05	--
Terminal Connections	--	--	0:05	--
Relays	--	--	0:10	--
	3:40	14:26	10:50	95:00
Travel Time*	<u>1:00</u>	<u>3:00</u>	<u>1:00</u>	<u>--</u>
	4:40	17:26	11:50	95:00**

Therefore, per year: $(4:40) \times 4 + (17:26) \times 2 + 11:50$
 $= 65:22 \text{ hours}$

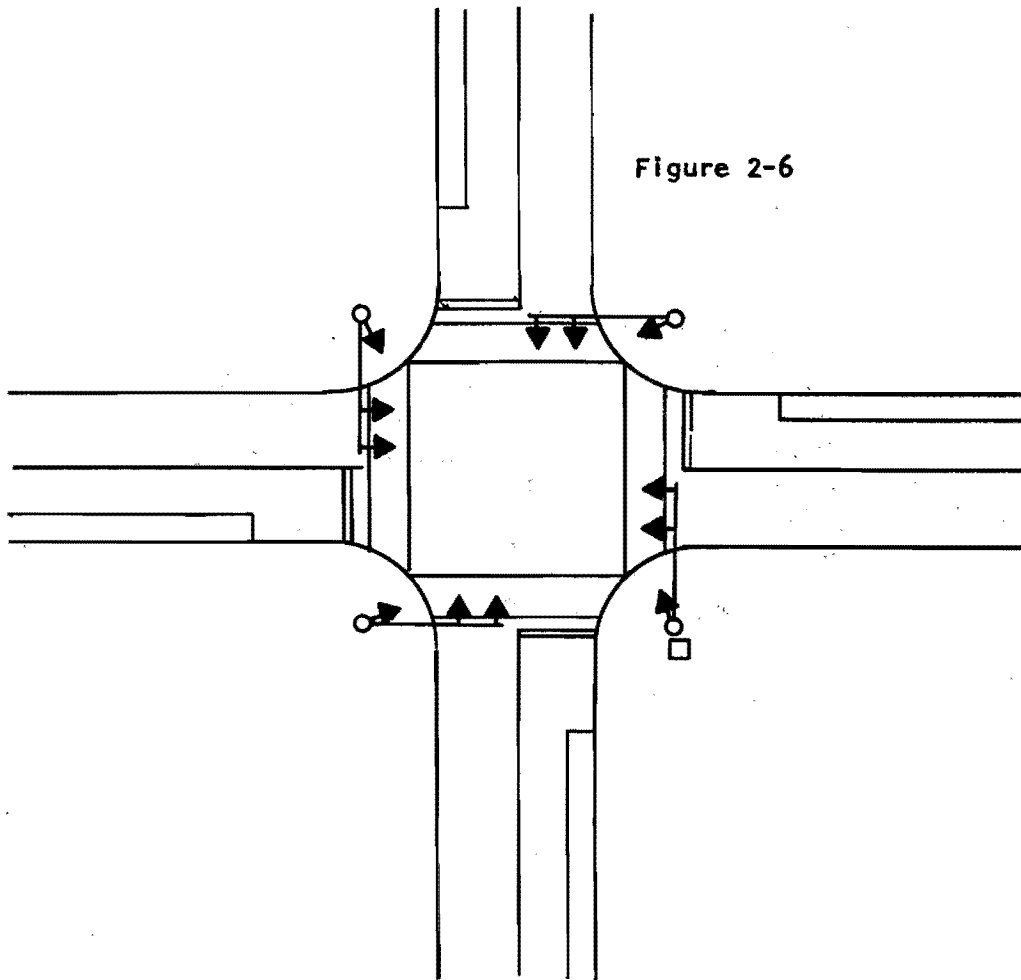
Record Keeping per year 3 hours

Total hours for
Preventive Maintenance
per year per
intersection 68 hours

*1 hour per 6.5 hours of working time
**2-5 years maintenance time is not included in the
yearly time estimates.

Case IV Intersection

Figure 2-6



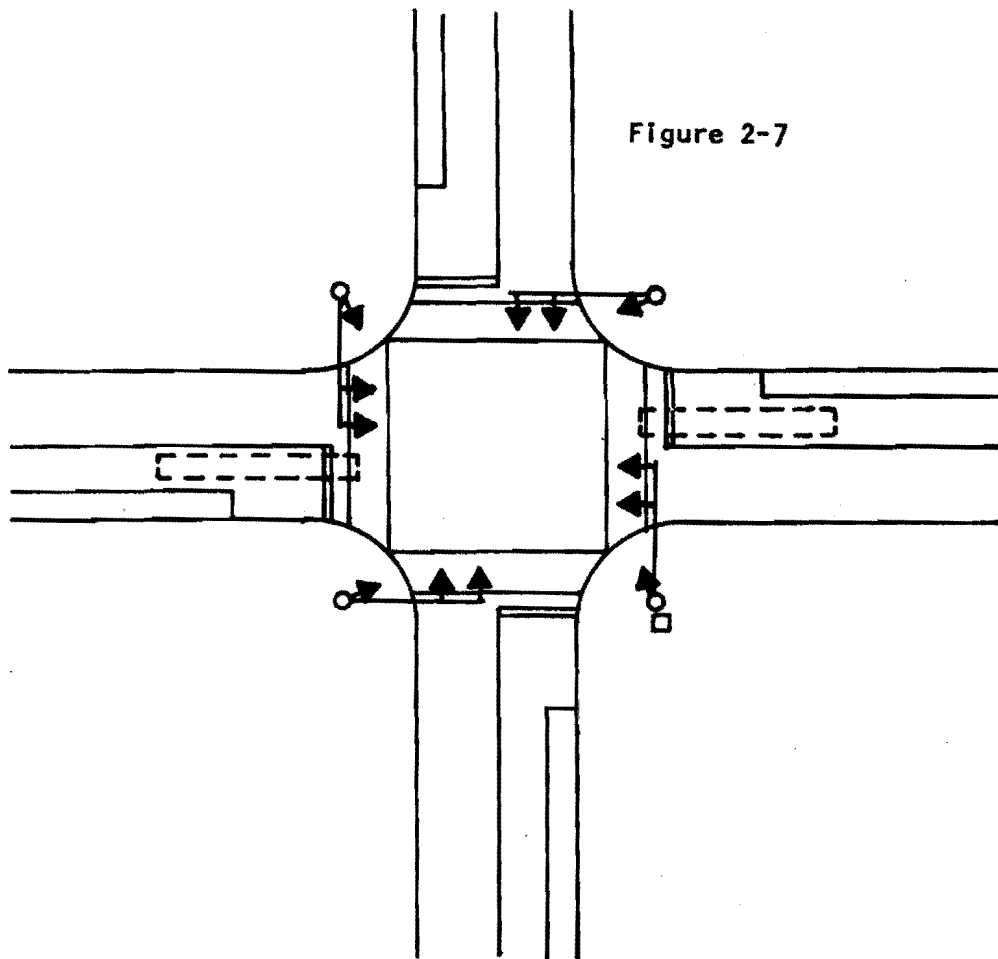
Intersection Estimates:

Same as Case I except the electromechanical controller is non-actuated and the two loop detectors (2 approaches) are deleted.

Total hours for
Preventive Maintenance
per year per intersection

31 hours

Case V Intersection



Intersection Estimates:

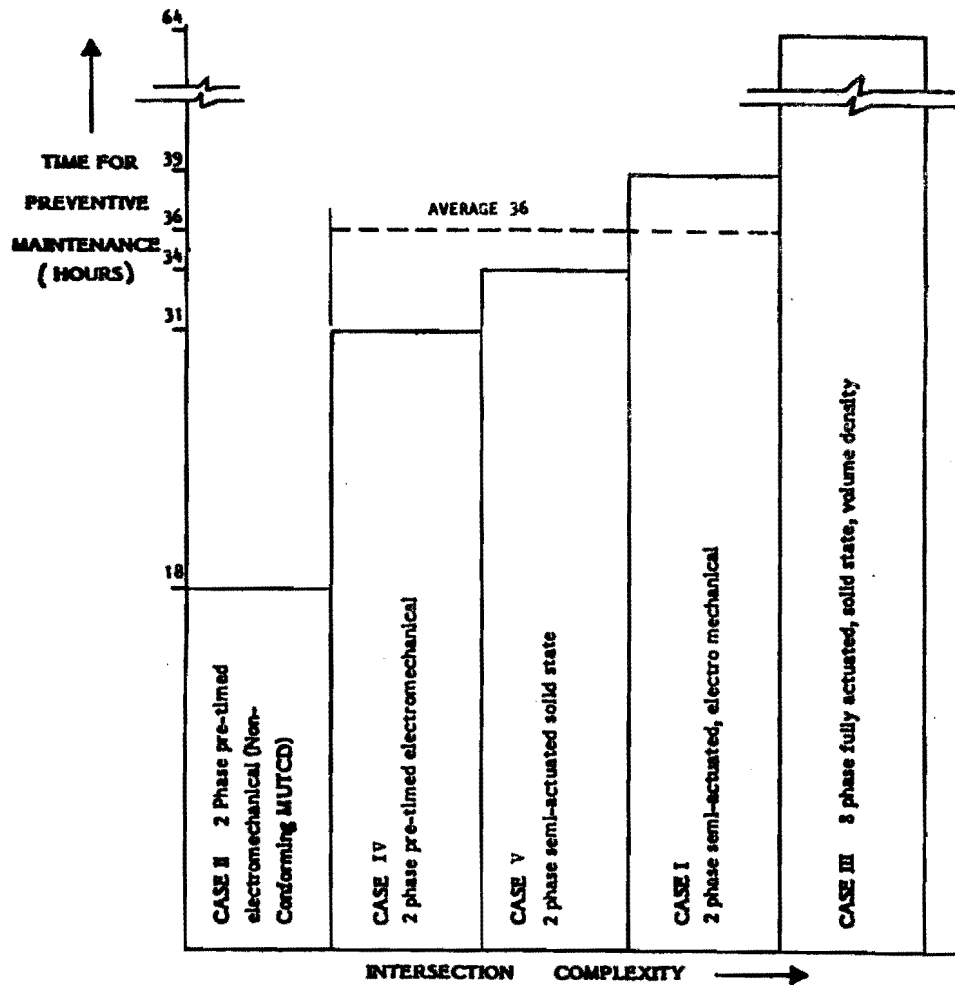
Same as Case I except that the electromechanical controller is replaced with solid state controller.

Total hours for
Preventive Maintenance
per year per
intersection

34 hours

2.7 ESTIMATED AVERAGE MANPOWER REQUIREMENTS PER INTERSECTION FOR PREVENTIVE MAINTENANCE

FIGURE 2-8



As the complexity of an intersection increases so does the time required for preventive maintenance. Only after taking a complete inventory of a municipality's traffic signal system, can one calculate the actual time needed per intersection for preventive maintenance. This average may vary greatly between municipalities. Therefore, we recommend using 36 hours per intersection for all calculations, which is the above average of the three most common types of intersection (i.e. I, IV and V).

3.1 DEFINITION OF RESPONSE MAINTENANCE

RESPONSE MAINTENANCE: The steps necessary to restore a traffic signal system to proper and safe operation. Includes Emergency Repair* and Final Repair.*

See 3.2 Priority Repair List For Type of Repair Permitted

FINAL REPAIR: (Conform to Permit)

Repair or replace failed equipment to restore system to proper and safe operation in accordance with permit within a 24 hour period.

EMERGENCY REPAIR: (Temporary)

Use alternate means or mode to temporarily restore system to safe operation within a 24 hour period. Final repair must then be completed within 30 days unless prohibited by weather conditions or availability of equipment.

- * Response time to the intersection to verify and identify the reported problem shall not exceed 1 hour.

3.2 PRIORITY REPAIR LIST
OF MAJOR ITEMS

TYPE OF REPAIR
PERMITTED

KNOCKDOWNS

Support - Mast Arm	Emergency or Final
Support - Strain pole	Emergency or Final
Span wire/tether only	Final Only
Pedestal	Emergency or Final
Cabinet	Emergency or Final
Signal heads only	Final Only

EQUIPMENT FAILURE

Lamp burnout (veh. & ped.)	Final Only
Local controller	Emergency or Final
Master controller	Emergency or Final
Detector sensor	
Loop	Emergency or Final
Magnetometer	Emergency or Final
Sonic	Emergency or Final
Magnetic	Emergency or Final
Pushbutton	Emergency or Final
Detector amplifier	Emergency or Final
Conflict monitor	Final Only
Flasher	Final Only
Time clock	Emergency or Final
Load switch/relay	Final Only
Coordination unit	Emergency or Final
Communication interface, modem	Emergency or Final
Signal cable	Final Only

3.3 LEVELS OF RESPONSE MAINTENANCE

LEVEL A: In Level A of response maintenance, the maintenance crew will be capable of complete repair and service of all electromechanical controllers, related systems and signals equipment. The failed components will be repaired or replaced and the operation returned to normal in the shortest possible time. All repairs of field returned electromechanical components will be performed in the workshop.

The maintenance crew will also be capable of repairing all solid state controller and any associated equipment in the field. The repair will be done in the most efficient manner and the operation returned to normal in the shortest possible time. Techniques used for trouble shooting may include swapping of modules, checking individual components or using other programmed modules. Any abnormal conditions that cause recurring problems will be identified and rectified.

Repair of all modules will be made in the workshop. The expertise of an electronic specialist will be used to the fullest, to repair failed modules in the shortest possible time. This will minimize the module inventory requirements.

Level A will require an electronic specialist and signal technician/signal mechanic.

LEVEL B: In Level B of response maintenance, the maintenance crew will be capable of complete repair and service of all electromechanical

controllers, related system and signals equipment. The failed components will be repaired or replaced and the operation returned to normal in the shortest possible time. All repairs of field returned electromechanical components will be performed in the workshop.

The maintenance crew will also be capable of repairing all solid state controllers and any associated equipment in the field, by swapping modules in the most efficient and skillful manner and returning the operation to normal in the shortest possible time. The maintenance crew will also be capable of trouble-shooting any abnormal conditions that may cause recurring problems. Simple repair of modules may be made in the workshop, however defective modules beyond the capabilities of repair in the workshop will be returned to the factory for repair. Inventory of various modules is required for swapping and replacement.

Level B requires a skilled signal technician.

LEVEL C: In Level C of response maintenance, the maintenance crew shall be capable of complete repair and service of all electromechanical controllers, related systems and signals equipment. The failed components will be repaired or replaced and the operation returned to normal in the shortest possible time. All repairs of field returned electromechanical components will be performed in the workshop.

For solid state controllers, repair will be made by swapping of devices, i.e. controllers, conflict monitors, detectors etc., until the defective device is identified and replaced. Defective devices are returned to the factory distributor for repair.

For troubleshooting and sophisticated control equipment, outside assistance will be required.

Level C requires the least skilled personnel, but requires a larger inventory of spare devices.

Table 3-1

RESPONSE MAINTENANCE LEVELS

		<u>Personnel Classification</u>
LEVEL A	- Same as level B, with occasional visit to the site by the specialist for trouble shooting - Repair of all equipment done in shop.	<u>Signal Specialist Signal Technician &/or Signal Mechanic</u>
LEVEL B	- Complete serviceability for electro-mechanical controllers/systems - Solid state or analog equipment field diagnostics by module exchange. - Systems and communications diagnostics	<u>Signal Technician & (if necessary) Signal Mechanic</u>
LEVEL C	- Complete serviceability for electro-mechanical controller or system. - Solid state and analog equipment field diagnostics by device exchange.	<u>Signal Mechanic</u>

The above levels of maintenance requirements will be used to evaluate the level of service that can be provided either by the municipality or by a contractor hired by the municipality.

4.1 PERSONNEL CLASSIFICATIONS

Personnel required for maintenance of traffic signal and control equipment (from here on referred to as the equipment), can be classified into categories based on their responsibilities, knowledge and skills:

1. **Signal Mechanic.** He will be completely responsible for the operation and troubleshooting of signals and electromechanical equipment. He will be responsible for response maintenance of solid state equipment up to the device exchange level in the field. He will be capable of diagnosing a vehicle loop failure and initiating corrective action. He will be able to tune detector amplifiers in the field. He will set and check the timing specified on the time plan sheets. He will have the ability to follow wiring schematics. He will be responsible for checking all field connections made and turn-on of the controller. He will also be responsible for periodic preventive maintenance of all equipment e.g. cleaning of lens, replacement of lamps, visors, aligning the signal head, checking and spot painting poles and mast arm brackets, cleaning of electrical contacts etc., to ensure reliable operation of the signalized intersections. He will maintain records of all work performed and of the equipment inventory.

He will be equipped with a service vehicle, test lamp, multimeter, standard tool kit and any additional tools as required.

2. **Supervising Signal Mechanic.** In addition to the responsibilities described for a signal mechanic, he will also be responsible for scheduling and recording work performed by himself and other signal mechanics in the group. He will prepare quantity and cost estimates for the annual budget.
3. **Signal Technician.** He will be responsible for maintenance of solid state equipment in the field. He will have the experience, knowledge and skills to efficiently identify a failed module or recurring failures at the intersection. He may use a diagnostics module (if available) to aid in identifying the failed module. He will have extensive experience and knowledge for the operation and troubleshooting of electromechanical equipment. He will have to perform tests on incoming equipment. He will not be a ladder man. He will be required to check and set controller timing as specified by the traffic engineer. He may have the additional responsibility of scheduling, supervising and recording work performed by the signal mechanics. He will be equipped with a multimeter, a portable scope, a standard tool kit and other test equipment as required.

4. **Signal Specialist.** He will have extensive training and troubleshooting skills in electronics and software. He will have a thorough knowledge of the theory of operations of the equipment. He will be responsible for the diagnostics and repair of all solid state equipment to the chip level. He may use a manufacturer's diagnostic module, if available, to aid him in identifying the problem. It will be his responsibility to repair all the modules in the shop. He will occasionally make field trips to aid the Signal Technician in returning the equipment to normal operation. He will design any jigs or test equipment that are needed in quickly diagnosing/repairing a problem.

He will implement the maintenance and repair record-keeping system. He will receive/ship equipment to the manufacturer and check any short shipments from the manufacturer. He will be responsible for the equipment incoming test. He is also responsible for a design review of the intersection/systems equipment for any recurring problems as a preventive maintenance procedure, e.g. loading of switch packs. He has the ability to make design modifications to implement or omit special functions, e.g., adding an overlap movement.

If the Signal Specialist is unable to identify the problem in the equipment, he will request factory assistance.

He will be equipped with accurate multimeter, oscilloscope, and other sophisticated meters deemed necessary, tools for removal and insertion of Integrated Circuits (IC), standard tool kit with a few additional tools to work on the IC's, and other test equipment as required.

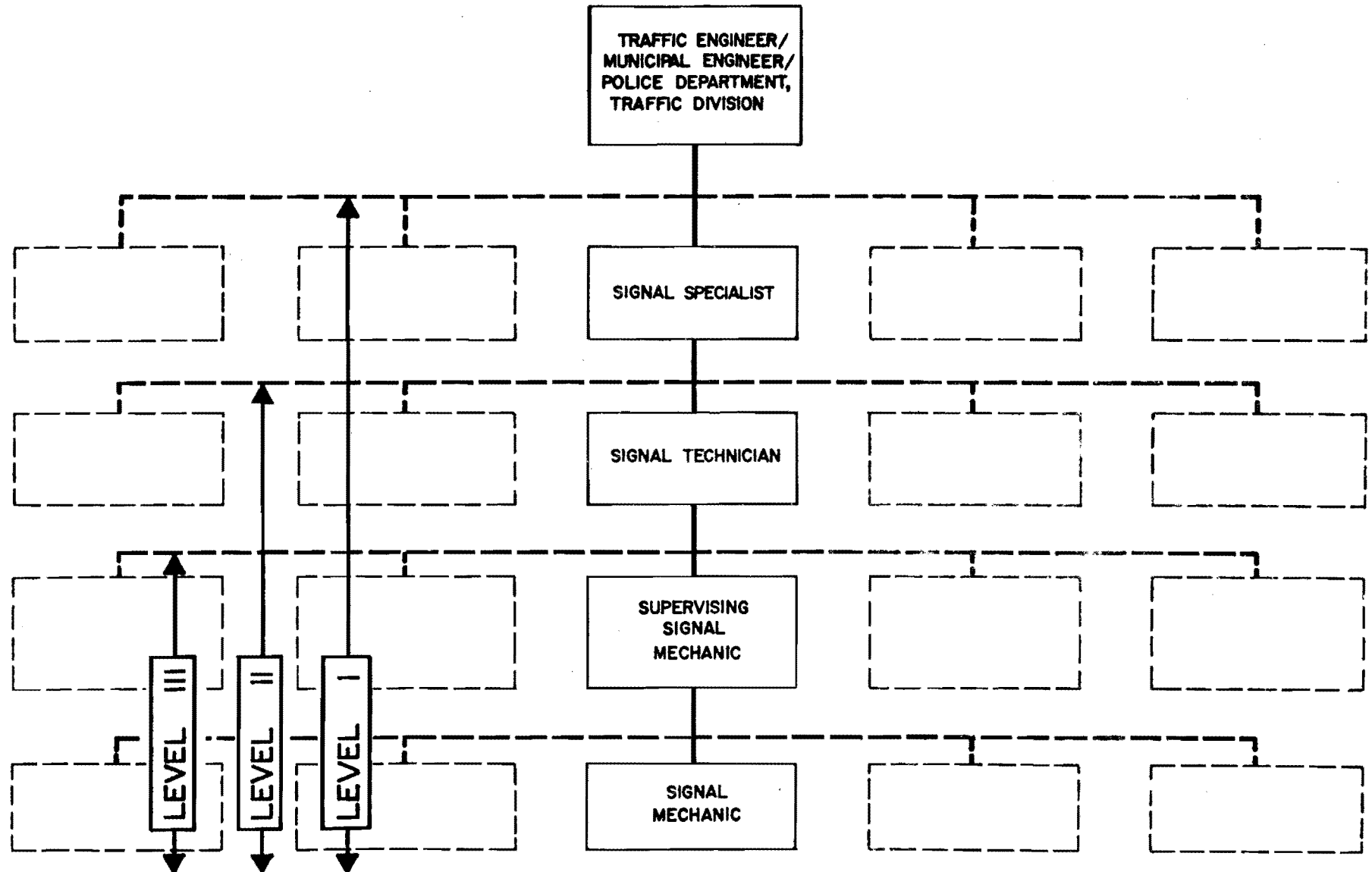
Basic assumptions made:

1. Detailed wiring diagrams are available.
2. Equipment is fully labeled.
3. Timing plans are developed by traffic engineers.
4. Maintenance manuals are available.

Definitions:

1. **Device.** A device is any circuit or module or set of modules enclosed in a single chassis and connected to other components in the cabinet via harnesses or wired connectors. e.g. controller, conflict monitor, flasher.
2. **Module.** Packaged functional assembly of electronic components for use with other such assemblies.

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
 MAINTENANCE OF TRAFFIC SIGNAL SYSTEMS
 ORGANIZATIONAL CHART



LEVELS OF OVERALL
 MAINTENANCE

TABLE 4-1

1

2

3

4

5

5.1 ESTIMATED ANNUAL MANPOWER COSTS FOR OVERALL MAINTENANCE

The following Tables in Section 5 are sample costs and time estimates for the purpose of showing the estimating procedure for annual manpower costs for overall maintenance. Each municipality should provide input for their individual time requirements and associated costs.

The annual productive work hours for maintenance personnel was estimated to be 1627 or 217 days per person (See Table 5-1). Using data obtained from Maintenance Questionnaire EK-29, (See Appendix I) the total time per intersection for preventive and response maintenance was estimated at 48 hours. Dividing the total time per intersection into the annual productive work hours resulted in the number of intersections that can be maintained by a single mechanic (See Table 5-2). Using the above information, a municipality can determine the most cost effective method of maintenance by comparing the municipal costs to contractor costs in their particular area.

TABLE 5-1

Estimated Annual Work Hours Per Person

Work Hours Per Year: 52 Weeks x 40 Hours	2080
Vacation: 3 weeks x 40 Hours	-120
Sick Leave: 2 weeks x 40 Hours	-80 (16.5%)
Annual Training: 1 week x 40 Hours	-40
Legal Holidays: 13 days x 8 Hours	-104
	1736
Coffee Break: .5 Hours per day x 217 days	-109
Total Productive Time	1627 Hours or 217 Days

TABLE 5-2

Estimated Maintenance Time Distribution Requirements Per Intersection

Preventive Maintenance	36 hours** (75%*)
Response Maintenance	<u>12 hours</u> (25%*)
Total Time/Intersection	48 hours (100%)
Estimated yearly hours per mechanic:	1627
Therefore the number of intersections that can be maintained by one signal mechanic:	$\frac{1627}{48} = 34$ intersections

TABLE 5-3

Estimated Annual Cost For a Signal Mechanic

Average salary per signal mechanic	\$16,000.*
+ 40% fringe benefits	\$ 6,400.
(Assuming no building rental)	
Assuming initial equipment cost: \$50,000.	
Prorated over 5 years	<u>\$10,000.</u>
Yearly expense for maintaining 34 intersections	\$32,400.

Evaluation of the break even line for maintenance by private contractor or municipality:
Annual maintenance budget: \$32,400.

Assume contractor rate:
\$30.00.

Then:

Hours of service with above budget $(32,400) \div 30 = 1080$ hrs.
75% of these will be spent on Preventive Maintenance = 810 hrs.
Each intersection requires 36 hrs. therefore the
total number of intersections serviced = 22.5
say 22

Thus if the number of intersections is greater than 22 it may be to a municipality's advantage to maintain these signals.

* Data obtained from Maintenance Questionnaire EK-29. ** Data obtained from averaging case estimates.

MASTER INTERSECTION RECORD OF

AND

INTERSECTION NUMBER

Reason For Intersection Inspection

	Date	Maintenance (Check Type Performed)		Design Modification (Include Brief Description)	Work Performed by (Signature)
		<u>Preventive</u>	<u>Response</u>		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

MAINTAINING AGENCY

6.2 RESPONSE REPAIR LOG ON SHEET

Called In By	DATE		Location	NO.		Trouble Record as Received	Actual Trouble as Found	Taken By	Person Assigned	Time Dispatched		Time Cleared	
	Date			A.M.	P.M.					A.M.	P.M.	A.M.	P.M.

6.3 RESPONSE MAINTENANCE REPAIR RECORD SHEET

INSTRUCTIONS: PLEASE FILL IN THE BLANKS AND/OR CHECK THE APPROPRIATE ANSWER(S).

MUNICIPALITY: _____			
LOCATION: _____		LOCATION NUMBER: _____	
DATE: _____			
REPORTED BY: _____ AT: _____ AM _____ PM		POLICE NOTIFIED: _____ AM _____ PM ☐ YES ☐ NO	
OFFICERS NAME AND RANK: _____			
REPORTED TROUBLE: _____			
WEATHER CONDITIONS: ☐ CLEAR ☐ RAIN ☐ SNOW ☐ ICE ☐ FOG			AMBIENT TEMPERATURE: _____ °F
GIVEN TO: _____ AT: _____ AM _____ PM		TRUCK NUMBER: _____	
CONDITION FOUND ON ARRIVAL: _____ _____ _____			TIME OF ARRIVAL _____ AM _____ PM
WORK PERFORMED: _____ _____ _____ _____			
☐ 1. Lamp Out ☐ 2. Detector Sensor Failure ☐ 3. Detector Amplifier Failure ☐ 4. Load Switch Failure ☐ 5. Conflict Monitor Failure ☐ 6. Timing Incorrect ☐ 7. Signal Stuck ☐ 8. Signal Out ☐ 9. Lack of Progression ☐ 10. Interconnect Failure ☐ 11. Systems Masters Failure ☐ 12. Power Failure ☐ 13. Signal Damaged ☐ 14. Pole Knockdown ☐ 15. Controller Knockdown ☐ 16. Guy Wire Down ☐ 17. Span Wire Down ☐ 18. Other _____ _____ _____ _____			
CONDITION ON DEPARTURE: _____ _____			TIME OF DEPARTURE: _____ AM _____ PM
☐ EMERGENCY REPAIR ☐ FINAL REPAIR			
PARTS REPLACED OR REPAIRED: _____ _____ _____ _____			
SIGNATURE OF SUPERVISOR: _____		SIGNATURE OF REPAIR PERSON: _____	

6.4 PREVENTIVE MAINTENANCE RECORD CODES

<u>Code</u>	<u>Description</u>
N	No maintenance function performed
C	Maintenance check or inspection performed with no anticipated problems - service at next regular interval
P	Possible problem - schedule additional Preventive Maintenance
I	Intermittent problem - schedule additional inspection or maintenance

6.5 PREVENTIVE MAINTENANCE RECORD

FOR THE INTERSECTION OF _____ & _____

MECHANICAL

CABINET

- o paint
- o oil hinges and lock
- o clean filter
- o replace filter
- o check weatherproof seal (gasket)
- o check anchor bolts
- o check for gas, water accumulation.
duct sealant
- o check ground rod clamp
- o wiring schematics and report
available and signed
- o check operation of fan and heater

SIGNAL HEADS

- o paint exterior of signal
- o clean lenses, signs and reflectors
- o replace lamps
- o check alignment
- o check for wear on the span wire and
the signal wire; check the mechanical
hardware (clevis pin, clamps)
- o check mast arms: free swinging signals -
check clevis and the chain
- o check for cracks or rust in the
hardware
- o check bent hoods, wing nuts, hinges
- o replace any parts not up to standard
- o check locking ring (surface); install
proper locking devices as required
- o perform a nighttime check for visibility

DATE	LEVEL OF MAINTENANCE	MAINTENANCE PERFORMED							
		RECOMMENDED INTERVAL							
		IN MONTHS							
		3	6	9	12	3	6	9	12
	A								
	A								
	A								
	B								
	A								
	A								
	B								
	A								
	A								
	A								
	A								
	A								
	B								
	B								
	B								
	A								
	A								
	A								
	A								
	A								
	A								
	A								

MAST ARMS AND POLES

- o paint
- o inspect for rust and spot paint as required
- o inspect the joints for rust and cracks
 - at arm/upright location
 - at base plate
- o inspect anchor bolts for rust and tightness
- o inspect the horizontal and vertical angle of the arm

SPAN WIRE AND POLES

- o refer to applicable pole section
- o check span wire
- o check clamps, hardware
- o check guy wire and the anchor

PUSH BUTTONS

- o check push button on each end of actuated crosswalks and visually verify pedestrian signal operation; verify timing
- o check push button lamp (if exists) for operation
- o check push button signs and clean if necessary
- o check push button signs alignment

DETECTOR SENSORS

- o make a visual inspection of the roadway along the saw cut for exposed wires, cracks, potholes, etc.
- o check alignment for sonic, magnetic and radar type detectors
- o check anchorage for pressure detector frame

DATE	LEVEL OF MAINTENANCE	MAINTENANCE PERFORMED							
		RECOMMENDED INTERVAL IN MONTHS							
		3	6	9	12	3	6	9	12
	A								
	A								
	A								
	A								
	A								
	A								
	A								
	A								
	B								
	B								
	B								
	B								
	A								
	A								
	A								

UNDERGROUND

JUNCTION BOXES AND HANDHOLES

- o check the integrity of the splices
- o check the ground rod and clamp connection, and bonding of conduits
- o check the insulation
- o check for abnormal amount of water
- o check lid for abnormal condition and fit

ELECTRICAL

- o check radio interference filter and lightning arrestor

ELECTROMECHANICAL CONTROL EQUIPMENT

Dial Assembly

- o check for wear on key follower
- o check for burned or pitted contacts and service contacts per manufacturer maintenance recommendations
- o check for key positions
- o check for cycle gear size and mesh
- o check dial motor operation
- o check all dials according to manufacturer's recommendations
- o if controller is part of a system, test offset
- o check duration of the advance pulse

Cam Assembly

- o check for end play
- o clean and lubricate as required by manufacturer
- o visually inspect for abnormal wear or cracks
- o visually inspect contacts for pitting/discoloration and service contacts per manufacturer maintenance recommendations

DATE	LEVEL OF MAINTENANCE	MAINTENANCE PERFORMED							
		RECOMMENDED INTERVAL IN MONTHS							
		3	6	9	12	3	6	9	12
	A								
	A								
	A								
	A								
	A								
	A								
	A								
	B								
	B								
	B								
	B								
	B								
	B								
	B								
	B								
	B								
	B								
	B								
	B								
	B								

		MAINTENANCE PERFORMED								
		LEVEL OF MAINTENANCE	RECOMMENDED INTERVAL IN MONTHS							
			3	6	9	12	3	6	9	12
DATE										
o	check spring tension on contacts	B								
o	check for any loose wiring contacts	B								
o	check for operation of advancing mechanism to conform with manufacturer's requirement	B								
o	check if all connections are secure and tight	B								
o	visually inspect wires for wear, rubbing, deterioration of insulation	B								
<u>Relays</u>										
o	check for burned and pitted contacts and service contacts per manufacturer's maintenance recommendations	B								
o	check for tight and secure fit into the sockets	B								
o	if latch type relays check for latch operation as per manufacturer's recommendations	B								
<u>Flashers</u>										
o	check flash rate	B								
o	check operation	B								
o	service contacts per manufacturer's recommendation	B								
o	check for tight and secure fit into sockets	B								
<u>Switches</u>										
o	verify operation of each switch position	B								
<u>Terminal Connections</u>										
o	check visually for signs of corrosion or any abnormal condition	B								
o	tighten all terminal connections	B								

	DATE	LEVEL OF MAINTENANCE	MAINTENANCE PERFORMED							
			RECOMMENDED INTERVAL IN MONTHS							
			3	6	9	12	3	6	9	12
<u>Conflict Monitor</u>										
o refer to solid state section										
<u>Detector Amplifiers</u>										
o refer to solid state section										
<u>SOLID STATE, ANALOG, AND MICROPROCESSOR BASED CONTROL EQUIPMENT</u>										
o check if the time settings match the master time sheet		B								
o check if all indicator lamps on the modules are working; replace failed lamps		A								
o check for extension by detector actuation		B								
o check if the modules are fitting tight and secure into the frame		B								
o check if the connector is tight and secure		B								
<u>Load Switches</u>										
o check if load switch packs are fitting tight and secure into the chassis		B								
<u>Conflict Monitor</u>										
o jump two conflicting green phases and check if conflict monitor responds; if it does, check if stop timing is implemented		B								
o if auxiliary logic package exists in the controller, check if conflict monitor detects a 24 VDC level drop		B								
o check if flash is activated		B								
<u>Flashers</u>										
o refer to electromechanical section										
<u>Switches</u>										
o refer to electromechanical section										

		MAINTENANCE PERFORMED									
		LEVEL OF MAINTENANCE	RECOMMENDED INTERVAL IN MONTHS								
			3	6	9	12	3	6	9	12	
DATE											
		B									
		B									
ns											
		A									
		A									
		A									

6.5 PREVENTIVE MAINTENANCE RECORD

FOR THE INTERSECTION OF MAIN ST. & HENDERSON

MECHANICAL

CABINET

- o paint
- o oil hinges and lock
- o clean filter
- o replace filter
- o check weatherproof seal (gasket)
- o check anchor bolts
- o check for gas, water accumulation, duct sealant
- o check ground rod clamp
- o wiring schematics and report available and signed
- o check operation of fan and heater

SIGNAL HEADS

- o paint exterior of signal
- o clean lenses, signs and reflectors
- o replace bulbs
- o check alignment
- o check for wear on the span wire and the signal wire; check the mechanical hardware (clevis pin, clamps)
- o check mast arms: free swinging signals - check clevis and the chain
- o check for cracks or rust in the hardware
- o check bent hoods, wing nuts, hinges
- o replace any parts not up to standard
- o replace lenses and reflectors if required
- o check locking ring (surface); install proper locking devices as required
- o perform a nighttime check for visibility

DATE	LEVEL OF MAINTENANCE	MAINTENANCE PERFORMED							
		RECOMMENDED INTERVAL IN MONTHS							
		3	6	9	12	3	6	9	12
		1-5-81	4-5-81	7-8-81	1-8-81				
	A								
	A				N				
	A		N		N				
	B				C				
	A				N				
	A				N				
	B				C				
	A				N				
	B		C		C				
	B		-		C				
	A								
	B				C				
	B				C				
	B		P	C	C				
	B								
	B		C		C				
	B		C		C				
	A		N		N				
	B		C		C				
	A		N		N				
	B		C		C				
	A		N		N				
	A		N		N				

MAST ARMS AND POLES

- o paint
- o inspect for rust and spot paint as required
- o inspect the joints for rust and cracks
 - at arm/upright location
 - at base plate
- o inspect anchor bolts for rust and tightness
- o inspect the horizontal and vertical angle of the arm

SPAN WIRE AND POLES

- o refer to applicable pole section
- o check span wire
- o check clamps, hardware
- o check guy wire and the anchor

PUSH BUTTONS

- o check push button on each ehd of actuated crosswalks and visually verify pedestrian signal operation; verify timing
- o check push button lamp (if exists) for operation
- o check push button signs and clean if necessary
- o check push button signs alignment

DETECTOR SENSORS

- o make a visual inspection of the roadway along the saw cut for exposed wires, cracks, potholes, etc., repair as required
- o check alignment for sonic, magnetic and radar type detectors
- o check anchorage for pressure detector frame

DATE	LEVEL OF MAINTENANCE	MAINTENANCE PERFORMED							
		RECOMMENDED INTERVAL							
		IN MONTHS							
		3	6	9	12	3	6	9	12
		1/8/	4/8/	7/8/	10/01				
	A								
	A				N				
	A				N				
	A				N				
	A				N				
	B				C				
	B				C				
	B				C				
	B		C		C				
	B		C		C				
	B		C		C				
	B		C	C	C				
	B		C	C	C				
	B		C	C	C				

[illegible]

- o check the integrity of the splices
- o check the ground rod and clamp connection, and bonding of conduits
- o check the insulation
- o check for abnormal amount of water
- o check lid for abnormal condition and fit

- o check radio interference filter and lightning arrestor

Dial Assembly

- o check for wear on key follower
- o check for burned or pitted contacts and service contacts per manufacturer maintenance recommendations
- o check for key positions
- o check for cycle gear size and mesh
- o check dial motor operation
- o check all dials according to manufacturer's recommendations
- o if controller is part of a system, test offset
- o check duration of the advance pulse

- o check for end play
- o clean and lubricate as required by manufacturer
- o visually inspect for abnormal wear or cracks
- o visually inspect contacts for pitting/discoloration and service contacts per manufacturer maintenance recommendations

	DATE	LEVEL OF MAINTENANCE	MAINTENANCE PERFORMED							
			RECOMMENDED INTERVAL							
			IN MONTHS							
			3	6	9	12	3	6	9	12
			1/8	4/8	7/8	10/8				
o check spring tension on contacts		B								
o check for any loose wiring contacts		B								
o check for operation of advancing mechanism to conform with manufacturer's requirement		B								
o check if all connections are secure and tight		B								
o visually inspect wires for wear, rubbing, deterioration of insulation		B								
o install dust cover as required		B								
Relays										
o check for burned and pitted contacts and service contacts per manufacturer's maintenance recommendations		B				C				
o check for tight and secure fit into the sockets		B				C				
o if latch type relays check for latch operation as per manufacturer's recommendations		B				C				
Flashers										
o check flash rate		B				C				
o check operation		B				C				
o service contacts per manufacturer's recommendation		B				C				
o check for tight and secure fit into sockets		B				C				
Switches										
o verify operation of each switch position		B				C				
Terminal Connections										
o check visually for signs of corrosion or any abnormal condition		B				C				
o tighten all terminal connections		B				C				

		MAINTENANCE PERFORMED								
		LEVEL OF MAINTENANCE	RECOMMENDED INTERVAL IN MONTHS							
			3	6	9	12	3	6	9	12
DATE			1/81	4/81	7/81	10/81				
		B				U				
		B				U				
		B								
		B								
		B								
		B								
		B								
		B								
		B								

DATE	LEVEL OF MAINTENANCE	MAINTENANCE PERFORMED							
		RECOMMENDED INTERVAL IN MONTHS							
		3	6	9	12	3	6	9	12

INTERCONNECTED EQUIPMENT

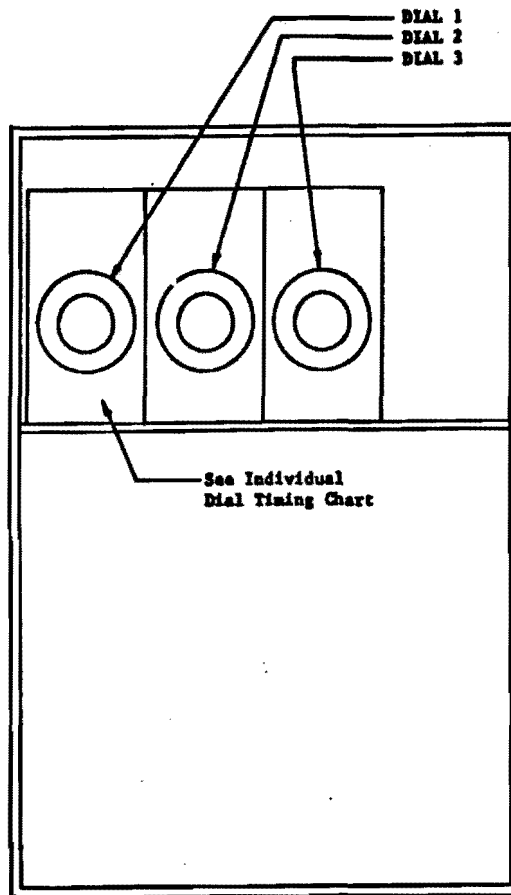
- o check if controller operates in the mode selected by the supervisory master
- o disconnect from the master supervisory system and check for "free" or backup operation
- o check any special equipment per manufacturer's recommendations

GENERAL

- o record all changes in: timing, wiring, or any function
- o periodically check the electric bill for leaky insulation

SIGNATURE OF SIGNAL MECHANIC PERFORMING PREVENTIVE MAINTENANCE									
John Woolley									
John Woolley									
James G. BLIN									
John Woolley									

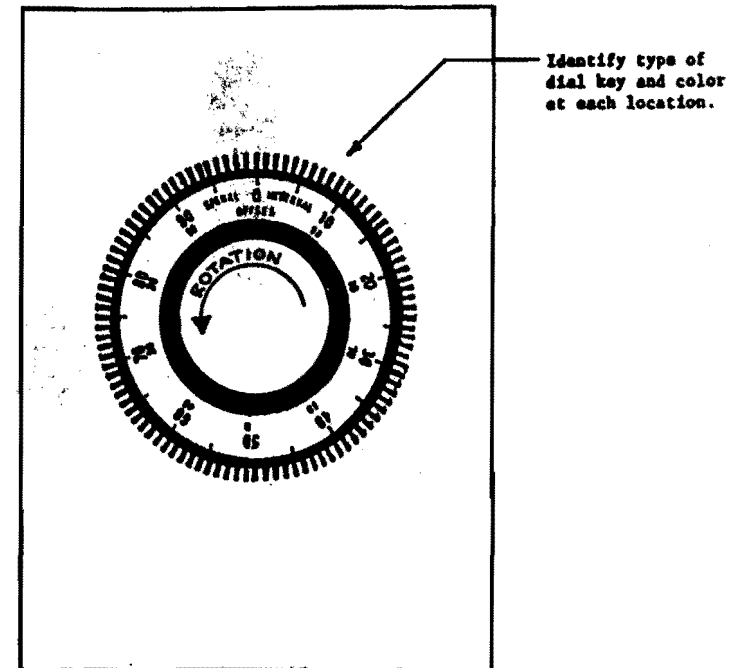
6.6 Controller Dial Chart



TIMING CHART

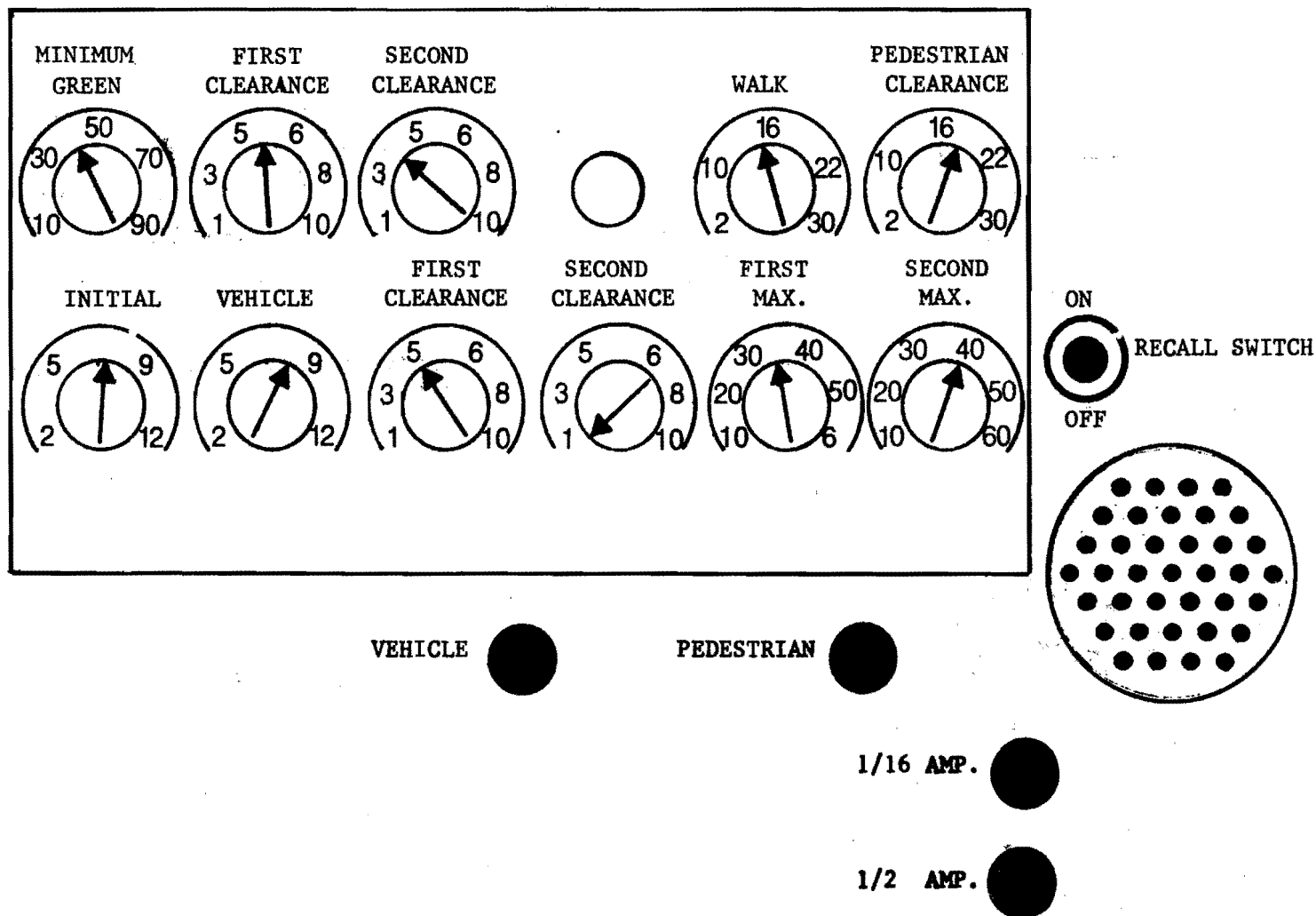
Intersection of _____
With _____
Number _____

6.7 Dial Timing Chart



TIMING CHART

Dial _____
Cycle Gear _____ Second



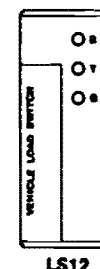
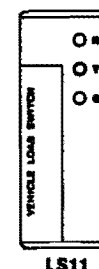
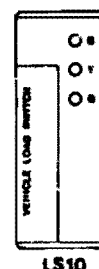
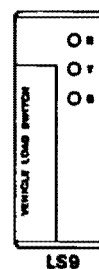
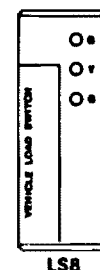
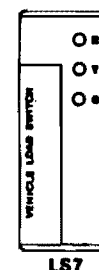
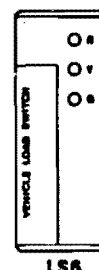
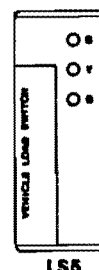
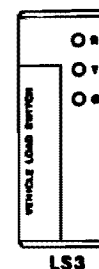
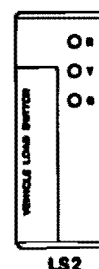
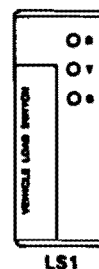
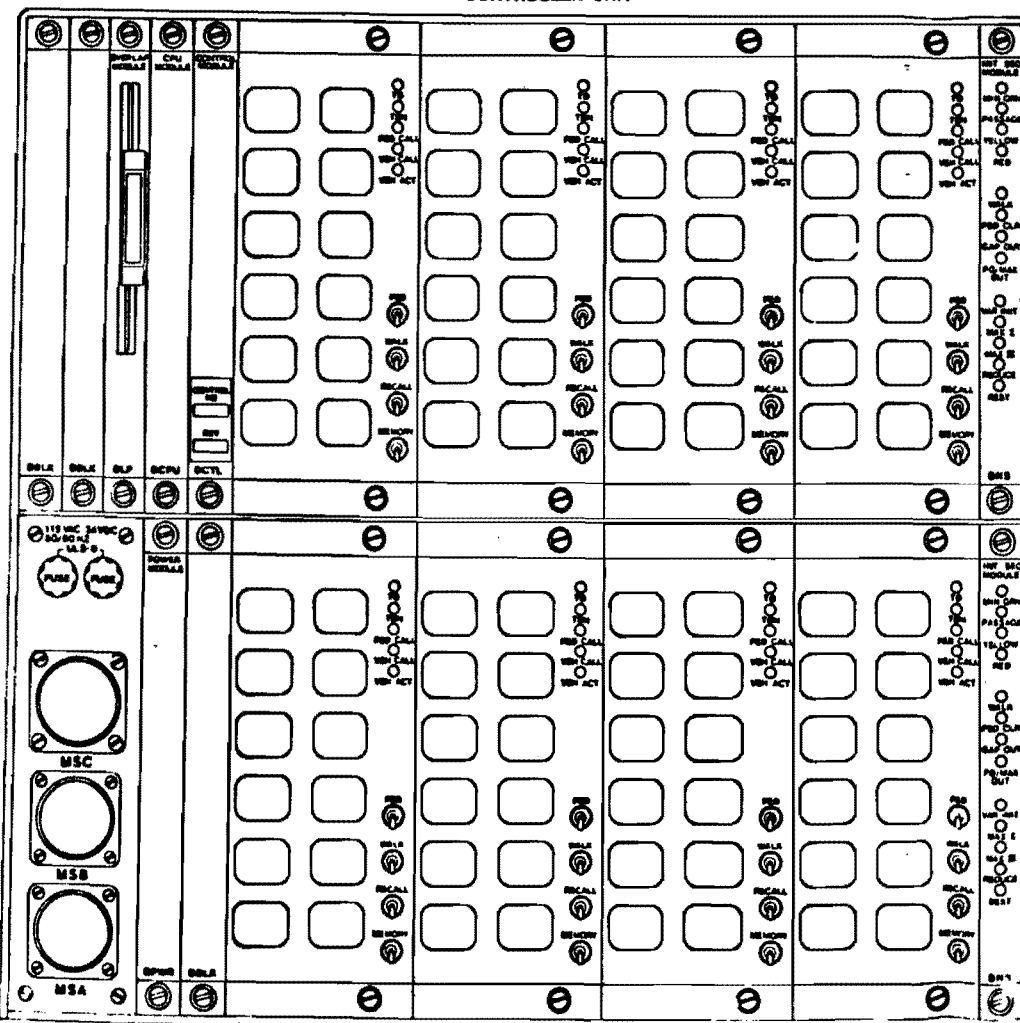
MASTER TIMING CHART

Intersection of _____

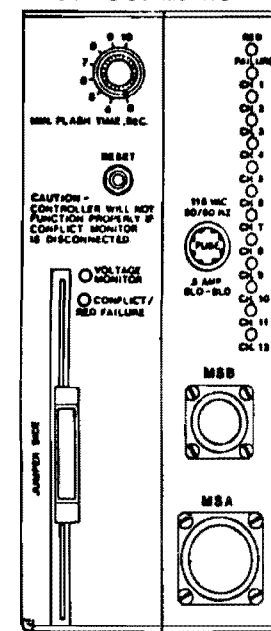
With _____

Number _____

CONTROLLER UNIT



CONFLICT MONITOR

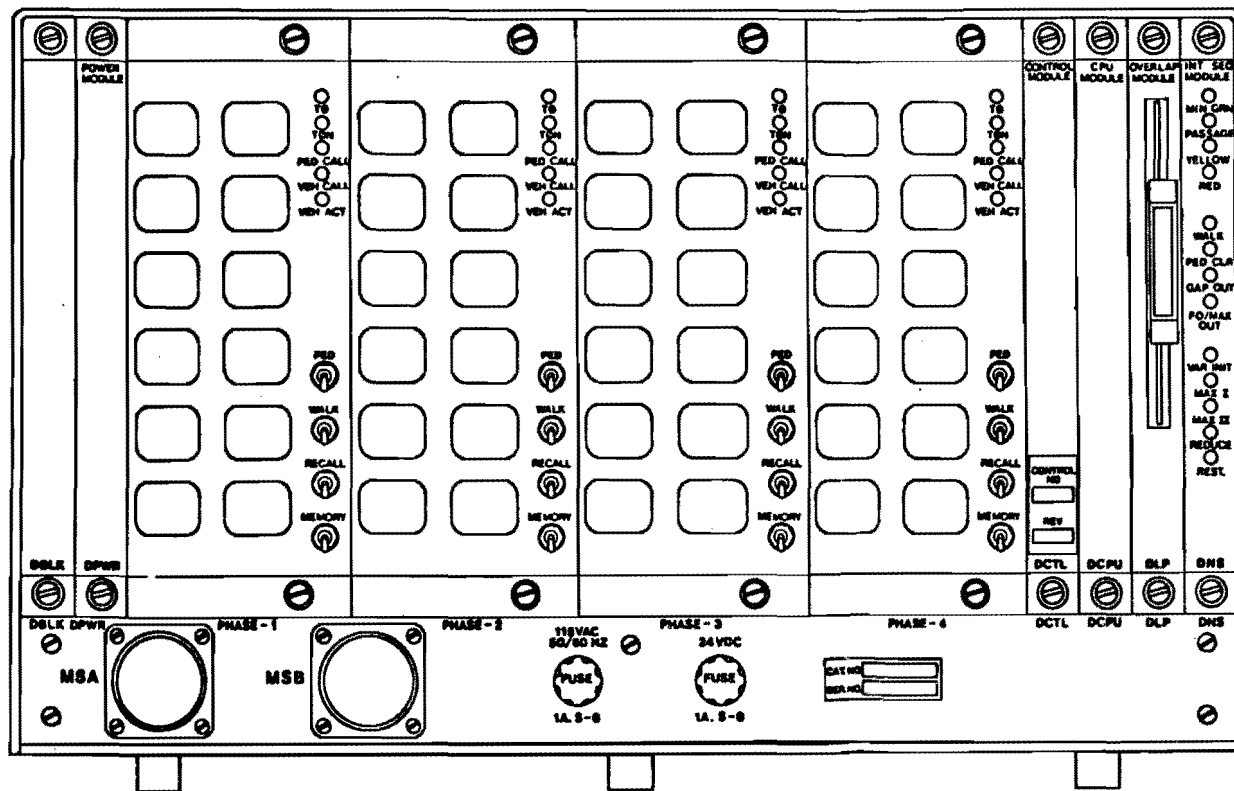


NOTES-

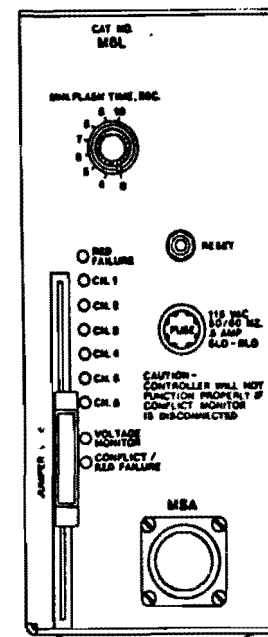
- 1- PLEASE X ALL L.F.D.'S THAT ARE ON DURING CONFLICT.
- 2- INDICATE TYPE OF PHASE MODULE(S) USED.
- 3- SHOW ALL TIMES IN PHASE MODULES.
- 4- SHOW WHAT POSITION RECALL SWITCHES ARE IN.

TITLE 6.9 SOLID STATE CONTROLLER MASTER TIMING CHART		NAME
INTERSECTION		DATE
Provided by Crouse Hinds		

CONTROLLER UNIT



CONFLICT MONITOR

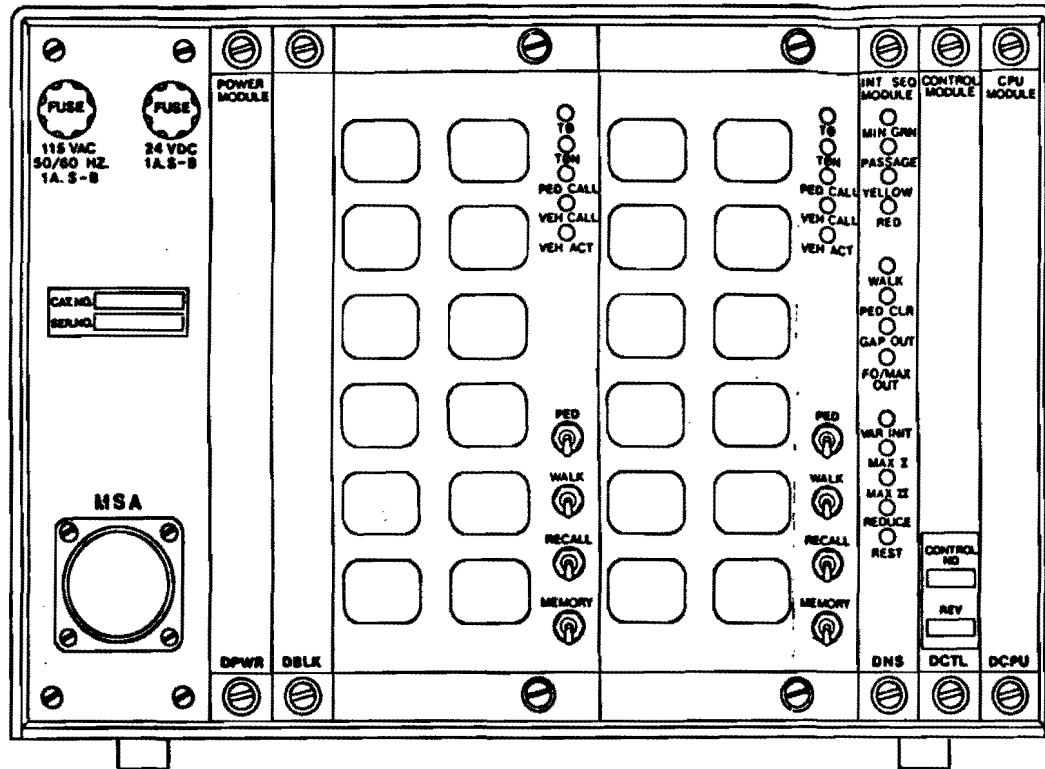


NOTES-

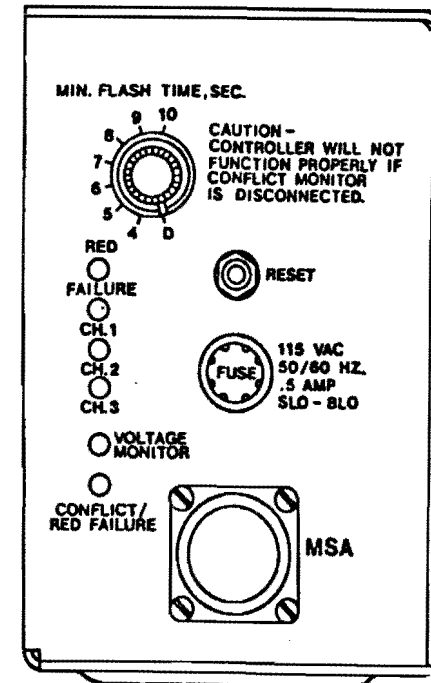
- 1-PLEASE X ALL L.E.D.'S THAT ARE ON DURING CONFLICT.
- 2-INDICATE TYPE OF PHASE MODULE(S) USED.
- 3-SHOW ALL TIMES IN PHASE MODULES.
- 4-SHOW WHAT POSITION RECALL SWITCHES ARE IN.

TITLE	NAME
6.9 SOLID STATE CONTROLLER MASTER TIMING CHART	DATE
INTERSECTION	
Provided by Crouse Hinds	

CONTROLLER UNIT

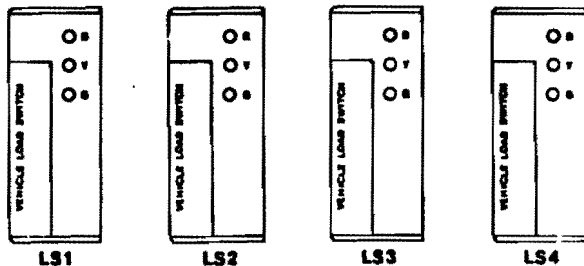


CONFLICT MONITOR



NOTES-

- 1- PLEASE X ALL L.E.D.'S THAT ARE ON DURING CONFLICT.
- 2- INDICATE TYPE OF PHASE MODULE(S) USED.
- 3- SHOW ALL TIMES IN PHASE MODULES.
- 4- SHOW WHAT POSITION RECALL SWITCHES ARE IN.



TITLE		NAME	
6.9 SOLID STATE CONTROLLER MASTER TIMING CHART		DATE	
INTERSECTION			
Provided by Crouse Hinds			

7.1 CONTRACTOR MAINTENANCE RECOMMENDATIONS

Upon evaluation of the capabilities and requirements of a municipality, the maintenance of traffic signals and control equipment may be assigned (let) to a private contractor. The following recommendations may be included in the scope of work outlined in the contractual agreement:

1. **Preventive Maintenance** Level A or Level B as outlined in Preventive Maintenance Summary shall be performed by the contractor. This contract may be on a yearly basis. Material for the preventive maintenance may be supplied either by the municipality or the contractor.
2. **Response Maintenance** shall be performed by the contractor on a per call basis. Upon notification of failure of an intersection signal or control by the Municipal Engineer/Police, the contractor shall dispatch qualified personnel to the location within an agreed upon limit of time, to identify the problem and take proper measures. The intersection failure shall be corrected by the end of the next working day.

Various contractor maintenance options are available to the municipality and are depicted in Figure 7-1. The municipality should choose an option which is compatible with their individual requirements.

7.2 Contractor Maintenance Options

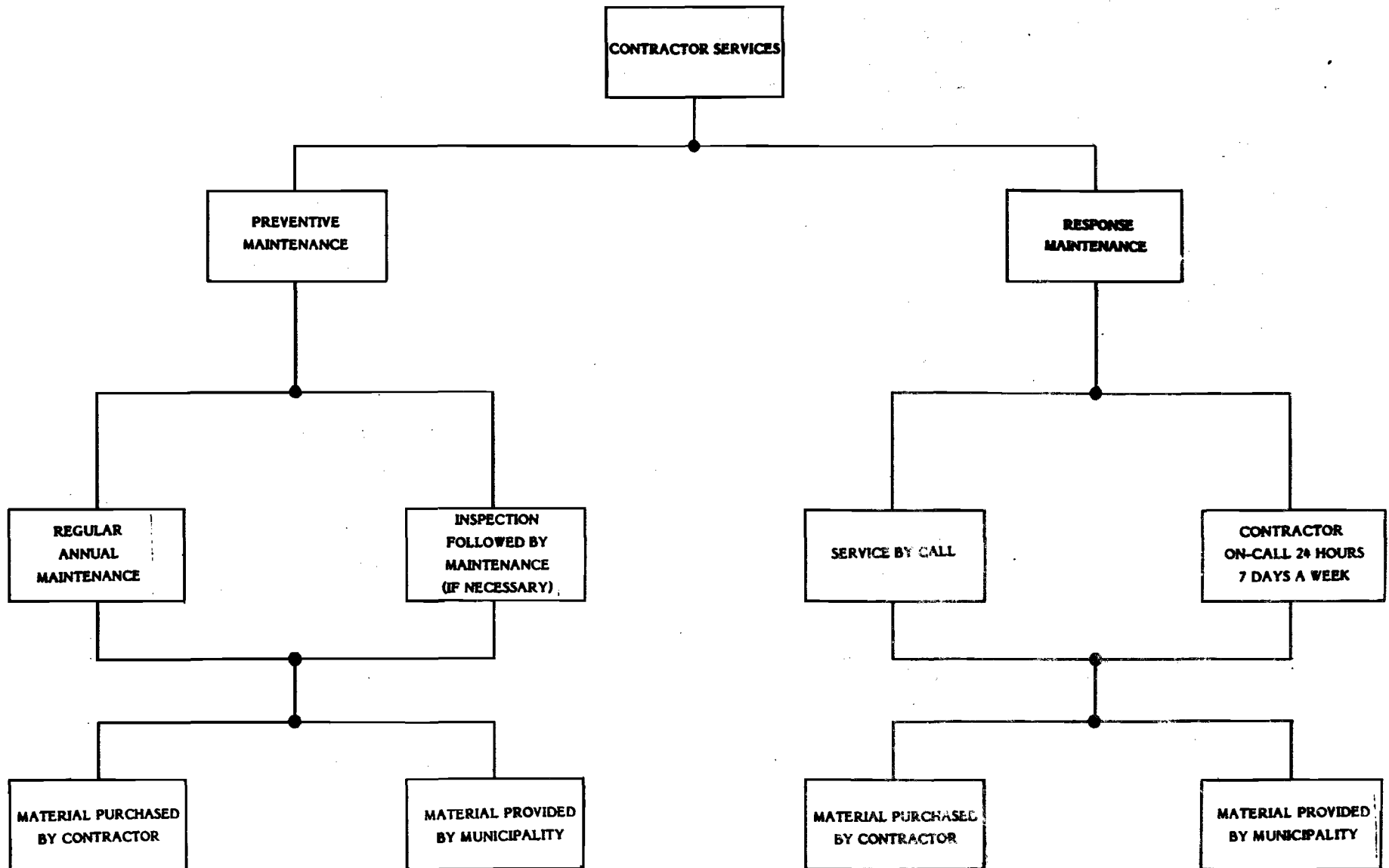


Figure 7-1

7.3 CONTRACTOR SPECIFICATIONS

GENERAL PROVISIONS

Work To Be Performed

The work to be performed shall include preventive and/or response maintenance at the locations listed in Table 7-1. The attached addendum includes the estimated total number of hours required for preventive maintenance for each intersection.

New Installation, Increased or Decreased Quantities

Whenever the quantity of work listed in the attached addendum is increased or decreased due to addition or deletions of installations, the Municipality will notify the Contractor in writing. This notification shall give the following information: (1) A description of the installation, unit or item to be added or removed, (2) the location of the installation, unit, or item, and (3) effective date of change.

Additional Awards of Contracts

The Municipality may undertake or award other contracts for additional work. The Contractor shall cooperate fully with such other contractors and Municipal employees and fit his own work to such additional work as may be directed by the Engineer. The Contractor shall not commit or permit any act which will interfere with the performance of work by any other contractor or by Municipal employees.

The Municipality also reserves the right to solicit and award contracts for the purchase of materials to be used by the contractor, when determined to be in the best interest of the Municipality. The contractor shall be allowed one (1) hour at the lowest Hourly Repair Charge rate for obtaining and transporting the materials from the municipal shop.

Inspection

The Municipality reserves the right to assign an inspector to the contractor's operation for the purpose of determining compliance with the specifications and maintaining records, including the time records for service charges. Any work or materials found to be substandard or not in accordance with the provisions of this contract, shall be repaired or replaced to the satisfaction of the Municipality at the sole expense of the contractor.

Work Performance

It shall be the contractor's responsibility to insure that he does not damage any material, equipment or structure during his operations, and he shall be held liable for any damage that he causes. If the contractor damages any materials, equipment or structure, he shall repair or replace it to the satisfaction of and at no expense to the Municipality.

All electrical work shall meet the electrical regulations of all state and local codes and otherwise as contained in the latest edition of the National Electrical Code of the National Board of Fire Underwriters.

All work shall be performed in a neat and workman-like manner. All material or equipment replaced, shall be held available for inspection by the Municipality prior to disposal by the contractor.

Maintenance and Protection of Traffic

The maintenance and protection of traffic during preventive maintenance shall be the responsibility of the contractor in accordance with Bulletin 43 and/or PDT Publication 90 of the Pennsylvania Department of Transportation. The contractor will be allowed to close one (1) lane of traffic, when necessary to provide the service required under this proposal, between the hours of 9:30 AM and 3:30 PM Monday through Friday, except holidays

Damaged Parts, Materials and Equipment

Surplus or damaged parts, materials or other equipment which are salvageable shall be taken by the contractor to a place designated by the Municipality unless indicated otherwise. Any damaged poles, broken concrete, or other such materials that cannot be repaired shall be disposed of by the contractor.

Method of Payment

The method of payment shall conform to the type of maintenance performed as outlined in the agreement.

Transportation

The contractor shall be responsible for providing transportation. There shall be no additional charge for transportation.

Test Equipment and Tools

The contractor shall provide all the necessary test equipment and tools as listed in the Pennsylvania Department of Transportation List of Equipment Requirements.

PREVENTIVE MAINTENANCE

Description of Work

Level _____ preventive maintenance as outlined by the Pennsylvania Department of Transportation shall be provided. All records and documentation shall be maintained as part of the contract.

Materials Supplied

The contractor shall procure all material required for maintenance of the signal and control equipment.

Methods of Payment

The estimate of total maintenance cost (less material) submitted in the bid or prepared by the Municipality shall be paid monthly upon receipt of a detailed report of work performed.

A separate invoice detailing the material shall be submitted to the Municipality.

RESPONSE MAINTENANCE

Description of Work

The contractor shall designate in writing an emergency telephone number where he may be contacted concerning response on-call service. The contractor shall be on-call twenty four (24) hours seven (7) days a week including holidays, for the purpose of making repairs. When a system or installation is not in operation or illuminated due to equipment failure or external damage, an authorized person (Engineer, Chief of Police) will notify the contractor of such failure. The contractor shall respond to correct the failure within a specified response time.

The response time for the contractor is classified into the following categories:

1. When notification is received between 7 AM - 4 PM Monday to Friday.

The response time shall be no more than one hour.

2. When notification is received any other time or day.

The response time shall be no more than four hours.

3. Emergency or dangerous situation exists, in which case the contractor shall immediately dispatch qualified personnel to eliminate such conditions.

The contractor shall restore normal operation in the field within 24 hours. In the event, the contractor is unable to restore normal operation in the field, a substitute controller shall be supplied at no additional cost to the Municipality until repairs to the existing controller can be made. Prior to the substitution, approval shall be granted by the Municipality. The existing controller shall be repaired and returned to the field in no more than fifteen (15) days.

All repairs and testing of the failed equipment shall be done by the contractor.

Complete record of the work performed and log-in sheet of the intersection shall be completed.

Material

All material for the repair shall be supplied by the contractor.

Method of Payment

Payment shall be made at the contract price per unit/hour for the respective item.

There will be a monthly service charge of _____ for the 24 hour on call service.

In addition there shall be a minimum service charge per call of 2 hours, regardless of the actual time spent.

The service charge time shall include only that time spent in repairing or restoring the installation. No compensation will be paid for break periods or down time.

A detailed description of the work performed and the material replaced shall be submitted with the bill.

A separate invoice detailing the material shall be submitted to the Municipality.

PENALTIES

If the contractor response time exceeds the time as outlined in the previous section, a penalty of _____ per each additional hour will be charged. If the contractor response time exceeds by 8 hours of the agreed upon limit, another contractor will be notified to repair the failed intersection at the expense of the original contractor. The Municipality shall deduct this amount from the contractor's monthly billing.

7.4 STANDARD PAY ITEMS

1. **Response Maintenance**

- | | | | |
|----|---------------------------------------|----|--------|
| a. | Hourly Repair Charge | \$ | /HR |
| b. | Hourly Overtime/Holiday Repair Charge | \$ | /HR |
| c. | Monthly Service Charge | \$ | /MONTH |

2. **Preventive Maintenance**

- | | | | |
|----|----------------------|----|-----|
| a. | Hourly Repair Charge | \$ | /HR |
|----|----------------------|----|-----|

Payment for material shall be at the invoice price plus shipping cost.

Table 7-1

LIST OF INTERSECTIONS INCLUDED IN MAINTENANCE CONTRACT

[illegible]