(d) **Finish.** The high mast lowering device shall be galvanized after fabrication in accordance with ASTM A-123-89a (AASHTO M-111-94)

813.04. CONSTRUCTION METHODS.

Recruit the services of the manufacturer's representative to assist in the proper installation of the lowering device. The manufacturer shall supply a written manual for installation and operation of the lowering device, with a minimum of 5 copies per project or one copy per device, whichever is greater.

Following the installation of the lowering device on the tower, but prior to its erection, request an inspection by the Traffic Engineer of the fully rigged device. Do not erect the tower without this inspection and/or approval by the Engineer. Take care not to damage the lowering device during the installation and erection of the tower.

813.05. METHOD OF MEASUREMENT.

The *high mast lowering device* will be measured by each unit of the size and type specified, installed in place, complete with all accessories, attachments, wiring, circuit breakers, etc., necessary to provide a complete mechanical and electrical system ready for connecting the high mast luminaires.

813.06. BASIS OF PAYMENT.

The accepted high mast lowering device, measured as provided above, will be paid for at the contract unit price bid as follows:

HIGH MAST LOWERING DEVICE ..... EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor, and incidentals required to complete the work, as specified.

SECTION 825
TRAFFIC SIGNAL CONTROLLER ASSEMBLY

825.01. DESCRIPTION.

This specification describes the minimum acceptable requirements for a full- traffic-actuated controller assembly with the options specified on the plans.

The controller assembly shall include a cabinet, a solid state full-actuated controller unit, load switches, flasher, conflict monitor, and pertinent documentation.

The controller assembly shall meet the requirements of NEMA (National Electrical Manufacturers Association) Standards Publication No. TS-1. In addition, all inputs and outputs to the controller unit shall conform to all interface and environmental standards in NEMA TS-1. Where a difference occurs, these requirements shall govern.

When called for on the plans, the controller assembly shall meet the requirements of NEMA Standards Publication No. TS-2.

Each controller unit shall have a unique serial number that is permanently and neatly displayed on the face of the unit.

825.02. MATERIALS.

(a) **Full-Actuated Traffic Signal Controller.**

1. Hardware Design Requirements. The controller unit shall be completely solid state and digitally timed. All timing shall be referenced to the 60 HZ power line. The dimensions of the controller unit shall not exceed 12 inch (0.33 m) height, 18 inch (0.44 m) width, 12 inch (0.33 m) depth.

   Build the controller unit using one or more circuit boards. All printed circuit boards shall be designed to plug into or out of a mother board or harness within the unit.

   NOTE: Power supply, transformers, capacitors, and heat-dissipating components are excepted from these requirements.

   The controller unit design shall allow for removal or replacement of individual circuit boards without having to unplug or remove other circuit boards. Also, one side of each board needs to be completely accessible for trouble shooting and testing the unit while it is still operating. This may be accomplished with extender boards or cables to be used on one circuit board at a time. When required, one set of extender boards for every 10 controller units ordered shall be provided with the order.

   A circuit assembly shall consist of two circuit boards attached to each other. The hardware used to attach them shall use captive nuts or another purchaser-acceptable method to secure the boards together. The boards shall be designed so that the purchaser can test and operate the controller unit with the boards separated. No circuit cuts shall be allowed on circuit boards in any of the equipment supplied. Any wire jumpers included on circuit boards shall be placed in plated through holes that are specifically designed to contain them.

   NOTE: Jumpers that are tack soldered to circuit traces or are added to correct board layout errors are not acceptable.

   All integrated circuits (IC's) with 14 or more pins shall be mounted in machine-tooled sockets. All sockets shall have two-piece, machined contacts and closed-end construction to eliminate solder wicking. The outer sleeve shall be brass with tin or gold plating and tapered to allow easy IC insertion. The inner contact shall be beryllium copper sub-plated with nickel and plated with gold. All sockets shall have thermoplastic bodies meeting UL Specification 94V-0. Other high quality sockets may be acceptable but must have prior approval of the Chief Traffic Engineer.

   NOTE: Zero insertion force sockets will not be allowed.

   Each of the following shall be displayed on the face of the unit:

   1. Phase(s) in service (one per ring)
   2. Phase(s) next to be serviced (one per ring)
   3. Presence of vehicle call (one per Phase)
   4. Presence of pedestrian call (one per phase)

5. Reason for green termination (one per ring)

Gap-out

Maximum time-out

Force-off

6. Pedestrian service (one per phase)

7. Max II in effect (one per ring)

Steady and flashing indications may be used for phase in service, phase next, and pedestrian service (walk, don't walk), or any other mutually exclusive indications.

Store and maintain user-programmed entries and timing settings in non-volatile memory.

NOTE: Battery power will not be allowed for this application.

All circuit components shall be of high quality and designed to withstand any of the environments and voltage conditions described in part 2 of NEMA Standard TS-1.

Design the controller unit to operate properly with the logic ground isolated from the AC Neutral (Common).

Provide a high quality keyboard with a rated lifetime of one million operations/key on the front panel of the controller unit. The keyboard shall be used for programming all user entered timings and settings. Provide a direct reading alphanumeric or graphic liquid crystal display with back lighting on the front panel of the controller unit.

The display shall have the following properties:

be clearly readable in ambient light including the cabinet light, in full sunlight, or in the absence of light from a distance of approximately 3 feet (1 m) at a 45 degree angle;

have an automatic time-out feature unless the display has an expected continuous life of 10 years or more;

have an operating temperature range of -30°F (-34°C) to 160°F (75° C);

blank out 10 minutes after the last keystroke is made;

have a minimum 40 character X 4 line display.

Demonstrate that all display requirements of this specification are met prior to acceptance. If an LCD contrast adjustment control is required for visibility at temperature extremes, then position the control, which must be adjustable without the use of tools, on the face of the controller unit.

Provide one spare set of all proprietary components including displays, IC's, and prom's for every ten controller units furnished or portions thereof, with a minimum of one set per project.

2. *External Download/upload Interface.* Have an RS 232 Serial port accessible through a DB-25S connector. The reserve connector pin assignments shall be as follows:

Pin	Designation
1	Frame Ground
2	Transmit Data
3	Receive Data

4 Request to Send
5 Clear to Send
6 Data Set Ready
7 Signal Ground
8 Data Carrier Detect
20 Data Terminal Ready
22 Ring Indicator

The minimum baud rate of the port shall be 2400 and shall be keyboard or jumper selectable. The port shall be configured for an 8 bit word, one (1) stop bit, no parity.

3. Program Requirements.

3.1 Programming/Data Entry. For programming of the controller unit, including TBC/BCT features, use a keyboard and display on the front of the controller unit. Programming shall require only simple keystrokes aided by full menu displays. For option start up programming, use internal dip switches.

NOTE: Ease of programming and ease in interpreting the display shall be required for acceptance.

The menu structure shall contain a main menu which contains options for all sections of the controller on one screen. Each option shall be selectable by a numeric entry. Each subsequent menu shall be a detailed breakdown of one of the previous menu options. Each menu option shall be a descriptive name to prompt the user to the desired section for programming. All entries shall be displayed and entered in plain English. Toggle type entries shall be set by entering yes/no or on/off responses. Non alphanumeric symbols used to display information shall be clear and unambiguous in their meaning. Numeric entries shall be in the base 10 (decimal) number system.

NOTE: Entries in other number bases such as hexadecimal or binary are not acceptable.

Each of the NEMA timing intervals shall be programmable for all eight phases from the same display screen in a spreadsheet format. The display may be rolled or paged down to display additional intervals or information.

A user selectable four digit (minimum) code shall be available to secure access to timing and configuration of the unit. Display features shall be available without the need to access the unit. Supply the controller units with the code preset to be all zeros (0000). Internal dip switches may be used to establish codes. Do not provide instructions for use of the access code on the face of the unit; instead, provide a keyboard-entered coded command (a series of commands or entries, not a single entry) which will set all controller and TBC timings and entries to a default or an inactive value. This coded command shall allow new values to be entered without first deleting prior entries.

The controller unit shall have a copying mode whereby the user, after having programmed all intervals of one phase, may copy this information into all or selected remaining phases. Other versions of the copying process that meet the functional intent are acceptable.

3.2 Operational Features. Provide volume density timing as specified in NEMA TS-1.

The controller unit shall be programmable for dual entry operations.

The following modes shall be available on a per phase basis:

1. Maximum Recall
2. Minimum Recall
3. Pedestrian Recall
4. Soft Recall
5. Detector Locking and Non-locking Memory
6. Phase Omit

The following configurations, as a minimum, shall be programmed within the controller unit and be user selectable:

1. 8 Phase NEMA
2. 8 Phase Sequential

The controller unit shall be designed to provide pedestrian phasing with any phase(s).

The controller shall be programmable for conditional servicing of left turns in the 8 phase NEMA configuration if the following conditions are true:

A. The opposing through movement has gapped out.

B. The compatible through movement green continues to extend.

C. The compatible through movement has adequate time on the max timer to service the turn's minimum time and the terminating through movement's amber and red times.

If a left turn is reserviced, the controller shall terminate the phases when the through phase gap termination or max termination point is reached.

The controller shall have user programmable detector assignments. Each detector shall be assignable to any phase for the purpose of calling or extending the phase. The default detector assignments shall be as defined by NEMA TS-1.

3.3 TBC/BCT. The TBC/BCT shall select and coordinate reversible left turn sequence operations (dual leading, leading and lagging, or lagging and leading left turns). It shall be possible to transfer operation from one sequence to another at a preprogrammed time. Transfer shall take place at the barrier following phases 1, 2, 5 and 6 or at T (0) as defined in section 3.4 below.

There shall be a pedestrian override mode in addition to any modes of operation described in this specification that operates as follows:

1. When no pedestrian calls are present, the normal phase timings programmed for a particular coordination plan shall be effective for service of the intersection.
2. When a pedestrian call is present, the call will be serviced by timing the programmed pedestrian times for that phase and override the normal split times. The intersection may drop out of coordination when servicing the call in this mode. The controller shall return to coordination in the manner described in this specification after the call is serviced. The programmed phase sequence may not be altered in reestablishing coordination.

3. When the intersection is being operated under computer control, this mode shall be ignored.
4. All timing entries required to operate in this mode shall be user programmable. The timings shall be programmable on a per phase basis. Normal pedestrian timing entries may be used for the pedestrian override timings in this mode (Special pedestrian timings are not required).
5. This mode shall be selectable by individual plan.

   A minimum of 36 patterns specifying cycle length, splits and offsets shall be required and consist of the following:

   1. A minimum of 4 cycle length selections each changeable from 30 to 200 seconds in one second increments.
   2. A minimum of three splits per cycle length selection.
   3. A unique offset for every cycle / split combination adjustable from 0 to 200 seconds in 1 second increments.

      The patterns not specified above can be achieved by additional cycle lengths, splits per cycle length selection, or offsets per cycle split combination.

3.4 Coordinator Operation. The coordinator shall reference a system wide reference cycle timer (system cycle timer). The term T (0) shall refer to the point in the local cycle timer when the coordinated phase (or leading coordinated phase if a pair of coordinated phases was selected by the user) is scheduled on for the first time. Note this may not be the beginning of green in the case of early return. In the event of early return to main street green, the pedestrian outputs shall not turn on until after a point when no other phases are allowed to be serviced before T (0). The offset shall be the amount the local cycle timer is behind the system cycle timer. Example: If the offset is +10 seconds, T (0) (the point at which the local cycle timer is at 0) will occur when the system cycle timer is at 10 seconds.

The following information shall be all that is required from the user to establish a pattern:

1. Basic NEMA controller timing.
2. Cycle length in seconds.
3. Phase sequence desired for the particular pattern.
4. Total seconds or percentage of the cycle that a phase is to be active including green, amber, and red times when there is a constant demand on all input detectors.
5. The offset of the first coordinated phase serviced in the sequence from the reference clock's T (0) in seconds.
6. Pedestrian override mode selection.

Using the above information, the coordinator must perform the following functions for each pattern:

1. Guarantee the coordinated phase(s) programmed time will be serviced in its entirety to achieve coordination between intersections. The programmed time of the first coordinated phase in the phase sequence shall start at T (0).

2. Calculate each phase's force off point (the point at which a phase's green must terminate in order to not violate the following phase's programmed times when calls exist).
3. Calculate the beginning of each phase's permissive window (the points in the cycle when each phase's preceding phase is allowed to yield to the phase).
4. Calculate the end of each phase's vehicle permissive window (the point preceding a phase's force off point by its minimum time and the prior phase's clearance time). Any phase receiving a vehicle call before the end of vehicle permissive window will be serviced during the current cycle.
5. Calculate the end of each phase's pedestrian permissive window (the point preceding a phase's force off point by pedestrian walk and pedestrian clearance times and the prior phase's clearance time). Any pedestrian call received by a phase before the end of pedestrian permissive window will be serviced during the current cycle.
6. Guarantee that each phase's programmed time be serviced in full if the call was received before the beginning of the permissive window and the phase does not terminate due to gap out.

No percentage inputs are allowable except for coordination phase times. Once the information for phase service is entered, the controller unit shall test the plan to insure that the plan does not violate any minimum times based on the specified numbers and cycle length. If a faulty plan is detected, the controller unit shall show an error code indicating the problem. If the error is not corrected, the controller shall run in the free mode of operation when the erroneous plan is selected. If pedestrian override has been selected, the coordinator shall ignore errors detected due to pedestrian times violating split times (see section (a) 3.3 for synchronization information).

The TBC/BCT shall be programmable to seek offsets by shortway (lengthening or shortening the cycle length up to 20%) and by dwell in the coordination phase awaiting the proper offset. The user shall determine which method and may program the longest permissible dwell times.

The TBC/BCT shall allow the following features and operations under time-of-day (T.O.D.) control:

Max II Timing
Gap/Ext II Timing
Phase Omit
Free Operation
Flash Operation

Transfer into and out of flash shall take place in a safe manner from any point in the phasing sequence. It shall be possible to program each phase and overlap to flash either yellow or red via the front panel of the controller unit. The flashing operation shall be accomplished by flashing the loadswitch driver outputs simultaneously.

The controller unit coordination program shall be designed to be programmed from the front panel to emulate the operation of a pretimed controller by recall or BCT for applications where no vehicle detection is provided.

Pedestrian movements for the main street shall rest in green and don't walk at points in the cycle where servicing the walk would violate other phases' permissive period unless the call to non-actuated function is active.

The internal reference sync pulse, from which the local offset is calculated, shall resync at midnight, or the resync shall be user programmable with default to midnight. A pulse shall be generated whenever the time-of-day clock shows a time which is an exact multiple of the current cycle length after this resynchronization.. In case of a power failure, resync shall be calculated from the programmed resync time. The power failure recovery routine shall accommodate the case of a power failure at midnight. If the TBC is operating in the free mode, the current cycle length will still cause a sync pulse to be output. This output will not cease due to preempt input, stop timing , manual control enable or any other command other than external start in which case all coordination outputs shall be false.

For each configuration the coordinated phase or phase pair shall be selectable from one of the individual phases or phase pairs shown in the following table:

CONFIGURATION

Coordinated Phase(s)	8 phase NEMA	Quad Sequential	8 Phase Sequential
Individual	2, 4, 6, 8	2, 4, 6, 8	2, 4, 6, 8
Pairs	2 & 6, 4 & 8	2 & 6	————

NOTE: Compatible phase pairs shall not be forced to begin simultaneously.

When establishing its offset from the reference point, the coordinator shall reference only the leading edge of the sync pulse, regardless of its width. Pulse width shall be a minimum of 1 second.

The internal coordination and upload/download programs shall be simultaneously operable and mutually non-interfering. The implementation of revised timing parameters loaded into the timer shall be programmed to occur only at points in the controller coordination cycles which do not alter the selected phase sequence. The controller unit may temporarily drop out of synchronization during the upload/download, but must continue to operate. A complete description of the upload/download format and protocol shall be supplied with the order.

3.5 Communication. Internal settings, including coordination, shall be accessible via an external modem through the RS 232 interface. All functions including detector actuation, signal indications, gap-out, max-out, minimum green, extensions, preempt and coordination synchronization status shall be displayed on the modem connected download/upload unit, or other compatible unit, in approximate real time on a graphical display of the intersection.

All alarms provided shall be accessible through the RS 232 port by remote interrogation and by automatic dialing initiated by the controller unit.

3.6 System Software. All software required to perform the functions described in section (a) 3.5 shall be provided as part of the controller software and shall be provided as a set consisting of the software on 3 1/2 inch (89 mm) disks. One set of software shall be provided for every ten controller units ordered. The Department reserves the right to make additional copies of this software for its own use.

4. Clock/Calendar Programming Requirements.

4.1 Clock Programming. The clock shall be easily set to the year, month, day of month, day of week, hour, minute, and second. The clock shall store an entire yearly program including dates and times for starting and ending daylight savings time (DST).

4.2 Clock/Calendar Adjustment. The dates for beginning and end of DST shall be keyboard programmable by the user. Dates for fixed and floating holidays and special events shall be user programmable. Calendar adjustments for leap years shall be automatic.

4.3 Clock/Calendar Structure. The clock shall store sequences of operations in the form of one yearly program, 10 weekly programs, 15 day programs and 30 exception programs. The structure and interrelationships of each type of program shall be in accordance with the following paragraphs.

A day program shall consist of the following:

Event 1, Event 2, and Event 10

where each event is unique. There shall be a minimum of ten events per day program. and a total of 15 day programs.

Each event in a day program shall consist of the following:

Time of Day
Cycle (1-4)
Offset (1-3)
Split (1-3)
MUTCD Flash (on/off)
Mode of Operation (a means of changing operating modes by TOD)
Special Function 1 (on/off)
Special Function 2 (on/off)
Left Turn Sequence (lead-lead/lead-lag/lag-lead)
Max II
Gap/Ext II

Any or all of these may be selected within a single event.

A Weekly Program shall consist of the following entries:

Sunday	-	Day Program 1-15
Monday	-	Day Program 1-15
Tuesday	-	Day Program 1-15
Wednesday	-	Day Program 1-15
Thursday	-	Day Program 1-15

Friday	-	Day Program 1-15
Saturday	-	Day Program 1-15
Monday through Friday	-	Day Program 1-15
All Days of the Week	-	Day Program 1-15

There shall be a total of 10 Weekly Programs.

A Yearly Program shall consist of up to 52 entries, each consisting of the following:
Starting Month (1-12)
Starting Day of Month (1-31)
Weekly Program Number (1-10)

There shall be 30 user programmable exception programs. The first 10 programs shall be programmable for the following standard holidays:

New Years Day
Labor Day
Martin Luther King Day
Columbus Day
Presidents Day
Veterans Day
Memorial Day
Thanksgiving Day
Independence Day
Christmas Day

The 30 exception programs shall be user programmable for both fixed and floating exceptions. Fixed exception format shall consist of the structure of a day program defined above, but shall also have a date (month/day of month) assigned to it indicating when it should override the normally operating program.

Floating exception format shall consist of the structure of a day program defined above, but shall also have a date (month/week of month/day of week) assigned to it indicating when it should override the normally operating program.

There shall be a copy feature that allows the transfer of entries between programs within the same program level (weekly program to weekly program, day to day, exception to exception). Other programming schemes that meet the functional intent are acceptable but require approval by the Chief Traffic Engineer.

5. Coordination Control Hierarchy. In the absence of any on-line control by a central computer, the internal TBC shall control the coordinated, free, and flash operation of the intersection when no 120 VAC conventional interconnect line inputs are present or when the interconnect free input is not present.

When the interconnect free input signal is present and the intersection is not under computer control, the controller unit shall be under the control of the master controller TBC.

When the central computer brings the intersection on-line, via the computer on-line input, its control shall supersede that of the internal time base or external conventional interconnect inputs.

For non-computerized applications where conventional 120 VAC interconnect lines are present, it shall be possible to operate the TBC and cabinet interface as provided both as a master for the conventional wire system, and as a local which will accept conventional cycle, offset, split, free/flash, and on-line commands from the interconnect line.

6. Preemption Programming Requirements. The internal preemptor supplied shall be easily programmable from the front panel for either railroad or fire run preemption sequences.

Phases shall be selectable such that a limited signal sequence may be operational during preempt (P.E.). It shall be possible to add phases to this special limited sequence which are not in the intersection sequence. This shall be accomplished without adding external logic.

The following intervals shall be provided as a minimum. Terminology may vary but the meaning must be clear. Additional unspecified intervals which may lead to confusion shall be programmable to zero. If three letter abbreviations or interval numbers are used on the display, they shall be defined on the front panel. While in preemption, the display will clearly identify the intervals being timed as preempt intervals. Yellow and red clearance from the phase timings may be utilized in place of the clearance intervals shown, providing all other preemption requirements are met.

TIMING INTERVAL	TIME	
INCREMENTS		
	(Seconds)	(Seconds)
0. Preempt Delay	0-99	1
(Emergency Vehicle Preempt)		
1. P.E. Minimum Green	0-9	1
2. P.E. Yellow	3-9.9	0.1
3. P.E. Red Clearance	0-9.9	0.1
4. Track Green	0-99	1
5. Track Yellow	0-9.9	0.1
6. Track Red	0-9.9	0.1
7. Minimum P.E. Duration	0-99	1
(Flash or Limited Cycle)	0-99	1
8. Return Yellow (Solid Display)	0-9.9	0.1
(Yellow after Limited Cycle Green)	0-9.9	0.1
9. Return Red Clearance	0-9.9	0.1
(Red after Flash P.E.)		

The phases to be serviced following the preempt sequence shall be front panel keyboard programmable.

Preempt sequences shall be selectable using external inputs. Preempt priority shall be assigned with No. 1 being the highest. If a higher priority preempt input is received during a preempt sequence the controller unit shall immediately clear to the next all red interval before entering the new sequence. The transition shall take place in a safe manner from any point in the sequence.

Preempt 1 shall be reserved for a priority railroad preempt. If more than two preempts are provided it shall be possible to delete the priority override for all but the railroad preempt. If a non-priority preempt is activated during another preempt cycle, the one in progress shall continue through its entire cycle. If the second preempt input is still active when the first one is completed, the controller unit shall go to all red flash or to the appropriate point in the non-priority preempt. When all preempt inputs are removed, the controller unit shall proceed through the normal sequence to return red clearance (Interval 9).

Once the controller unit has entered the first timed interval following preempt delay (Interval 1), the sequence shall continue to the end even if the preempt call is dropped. If the call returns or remains through the minimum preempt (Interval 7) the controller unit shall remain in this interval until the call is dropped.

The controller unit shall be programmable to be in flash or in limited sequence during Interval 7. If flash is specified, the phases shall flash yellow or red as programmed from the front panel. Flash shall be implemented by simultaneously flashing the appropriate loadswitch driver outputs and not be setting the voltage monitor output false. If limited sequence is selected, all phases shall be programmable even if not normally used in the intersection sequence.

6.1 All Intervals Are Sequential.

0. *Preempt delay* - This time shall start immediately when the preempt command is received. It shall not affect the normal operation of the controller unit until the delay time out occurs. This interval may be used for emergency vehicle (Fire Lane) Preemption delay. If 0 (Zero) time is set the interval shall be omitted.

1. *P.E. Minimum Green* - Any vehicle signal that is green at the time this interval becomes active shall not terminate unless it has been displayed for at least the time programmed in this interval. Walk/Walk clearance indications shall immediately change to Don't Walk at the end of this interval. If 0 (Zero) time is set the interval shall be omitted.

2. *P. E. Yellow Clearance* - Green signals not programmed as track or fire lane signals shall change from green to yellow. Red signals shall not change. Signals displaying yellow at the start of this interval shall remain yellow. All yellows, including those already yellow at the start of this interval, shall display yellow for a minimum of 3 seconds before leaving this interval. Walk/Walk clearance indications shall immediately change to Don't Walk at the beginning of this interval. Signals programmed as track or fire lane signals which are yellow shall remain yellow. Green and red signals shall not change.

3. *P.E. Red Clearance* - All yellow signals shall change from yellow to red. Red signals shall not change. Green signals shall not change.

4. *Track Green* - Signals programmed as track (or fire lane) signals shall remain green or be changed to green. All other signals shall be red. Intervals 4, 5, and 6 shall be optionally programmable to zero during emergency vehicle P.E.

5. *Track Yellow* - This interval is the yellow interval for the track (or fire lane) signals. All other signals shall remain red.

6. *Track Red* - This interval provides all red time for clearance of the track or fire lane.
7. *Minimum P.E. Duration* - The preempt sequence shall not terminate until the preempt input signal is removed, and the minimum duration time has expired. Each signal shall be keyboard programmable for red, red flash, yellow flash or green. As an alternative, a limited cycle shall be programmable for use with railroad preempts.
8. *Return Yellow Clearance* - This interval shall provide a solid yellow clearance for indications that were green or flashing yellow. Red and flashing red displays shall display solid red. This interval shall be skipped if programmed to zero.
9. *Return Red Clearance* - This interval shall be an all red clearance in preparation for return to the normal cycle. Return phases shall be programmable from the keyboard.

In the event of a power interrupt as defined in NEMA Standard Publication TS-1, if the preempt command is present when power is restored, the controller unit shall power up in all red flash operation and remain there until the P.E. command is removed.

Overlap phases shall begin and terminate with the parent phases as described in NEMA TS-1. If the P.E. call occurs during yellow or red displays between parent phases, the overlap phase shall display a minimum of 3 seconds of yellow and a minimum of 1 second of red clearance.

Don't Walk shall be displayed throughout the preempt sequence unless a limited cycle is run during P.E. Duration (intervals 2 through 9). During a limited cycle (interval 7) the pedestrian heads may be programmed to be dark.

Preempt routines shall have priority over all functions except for emergency and conflict flash.

The signal from the conflict monitor shall stop time the preempt cycle until it is removed or reset.

(b) **Cabinet Requirements.**

1. *Design Requirements*. The cabinet shall be constructed using unpainted sheet aluminum with a minimum thickness of 1/8 inch (3 mm). No wood, wood fiber products, or other flammable material shall be used in the cabinet. All welds shall be neat and of uniform consistency. The cabinet shall be completely weatherproofed to prevent the entry of water. All unwelded seams shall be sealed with a clear or aluminum colored weather-seal compound.

Vertical shelf support channels shall be provided to permit adjustment of shelf location in the field. The channels shall have a single continuous slot to allow shelves to be placed at any height within the cabinet. Channels with fixed notches or holes are not acceptable. There shall be sufficient shelf space to accommodate a controller unit 12 inches (0.30 m) high, a 12-channel NEMA conflict monitor, and 12 NEMA type loop detector amplifiers. Additional shelf space a minimum of 12 inch (0.30 m) high, 12 inch (0.30 m) wide, and 12 inch (0.30 m) in depth shall be provided.

The cabinet shall be vented and cooled by a thermostatically controlled fan. The fan shall be a commercially available model with a capacity sufficient to meet NEMA requirements but shall be at least 2 CFS (0.05 CMS). The thermostat shall be an adjustable type with an adjustment range of 70°F to 110°F (20° C to 43° C) The intake for the vent system shall be

filtered with an air conditioning filter. The filter shall be securely mounted so that any air entering the cabinet must pass through the filter. The cabinet opening for intake of air shall be large enough to use the entire filter. The air intake and exhaust vent shall be screened to prevent entry of insects. The screen shall have openings no larger than 0.012 square inch (8 square mm). The total free air opening of the exhaust vent shall be large enough to prevent excessive back pressure on the fan. The minimum filter dimensions shall be 15 inch (0.40 m) wide by 12 inch (0.30 m) high by 1 inch (25 mm) thick, for base mounted cabinets.

The cabinet shall be provided with a unique serial number which shall be stamped directly on the cabinet or engraved on a metal or metalized Mylar plate, epoxied or riveted with aluminum rivets to the cabinet. The digits shall be at least 1/4 inch (6 mm) in height and located on the upper right sidewall of the cabinet near the front. A ground fault circuit interruption GFCI) type duplex receptacle shall be mounted and wired in the lower front right side wall of the cabinet. This receptacle shall be wired on the load side of the 20 amp circuit breaker.

2. *Back Panel.* The back panel shall be designed to accept the minimum load switches as required on the plans. The back panel shall be hinged at the bottom and shall fold down and out from the top for maintenance with all components (load switches, relays, etc.) in place. It shall be possible to gain full access to the back of the back panel in less than two minutes, using simple tools. Wire termination points on the back of the back panel shall be numbered or identified to correspond to the labeling on the face of the panel. No printed circuit back panels shall be permitted. No components shall be mounted behind the back panel. Transient suppression devices for relay coils are excepted from this requirement.

   The outputs from the controller to the load switches, and outputs from the detectors to the controller, shall be brought through posted binder head screw terminals with removable shorting bars installed. The load switches and flasher shall be supported by a bracket(s), designed to accept all NEMA type load switches and flashers, that will support the switch and prevent vibration from dislodging it from the socket in the back panel. The load switch outputs shall be brought out through posted binder head screw terminals. Field wiring for the signal heads shall be connected at this terminal strip. If the phasing on the plans require additional load switches, they shall be provided. The cost is to be included in the bid price of the controller.

3. *Detector Panel.* The cabinet shall have a loop detector panel mounted on the left side of the cabinet. This panel shall provide for all connections between loops at the street and the detector amplifiers, pedestrian call isolation, and connection between detector amplifiers and controller unit. Three position detector test switches shall be provided in the cabinet.

   Inputs from the loops shall be brought through posted binder head screw terminals. The outputs from the detectors to the controller shall be brought through posted binder head

screw terminals with removable shorting bars installed. The detector harnesses shall be equipped with an MS3106A-18-1S connector and shall be wired as follows:

PIN NO.	FUNCTION
A	AC Common
B	Controller unit logic ground
C	120 Volts AC
D	Loop
E	Loop
F	Controller detector call input
G	Spare
H	Ground bus
I	Controller detector call input
J	120 Volts AC output from green load switch for this phase

An on-off-momentary toggle switch shall be provided for each vehicle and pedestrian phase to permit the user to disconnect the input from the detector for that phase from the controller unit, or permit the user to place a call to the controller. The momentary position shall place a call to the controller. The on position shall connect the detector to the controller unit. The center off position shall disconnect the detector from the controller unit.

If a detector rack is used, Section 828 shall be in effect for the detector panel, loop amplifiers, and all associated wiring.

4. *Cabinet Door*. The cabinet shall be provided with one door in front that will provide access to the cabinet. The door shall be provided with three hinges with nonremovable stainless steel pins, or a full length piano hinge with stainless steel pins spot welded at the top of the hinge. The stainless steel pin shall conform with ASTM A320 B8F. The hinges shall be mounted so that it is not possible to remove them from the door or cabinet without first opening the door. The bottom of the door opening shall extend at least to the bottom level of the back panel.

The cabinet door shall be fitted with a Number 2 Corbin type lock and a cast aluminum or chrome plated steel handle with a 3/4 inch (19 mm) minimum shaft and a three point latch. The lock and latch design shall be such that the handle cannot be released until the lock is released. One key shall be provided for each cabinet. The lock shall be located to be clear of the arc of the handle. The door handle shall be stainless steel to prevent rusting and shall be capable of being padlocked in the closed position.

A gasket shall be provided to act as a permanent dust and weather resistant seal at the controller cabinet door facing. The gasket material shall be of a nonabsorbent material and shall maintain its resiliency after long term exposure to the outdoor environment. The gasket shall have a minimum thickness of 3/8 inch (9 mm). The gasket shall be located in a channel provided for this purpose either on the cabinet or on the door(s). An “L” bracket is acceptable in lieu of this channel if the gasket is fitted snugly against the bracket to insure a uniform dust and weather resistant seal around the entire door facing.

A locking auxiliary police door shall be provided in the door of the cabinet to provide access to a panel that shall contain a signal shutdown switch, a signal flash switch, and a manual-automatic switch. A standard 1/4 inch (6 mm) 2-Conductor phone jack shall also be

provided to accept a manual push button. The police door shall be gasketed to prevent entry of moisture or dust and the lock shall be provided with one brass key.

A heavy gauge vinyl plastic pouch shall be riveted to the inside of the cabinet door. The pouch shall be approximately 12 inch x 17 inch (0.30 m x 0.43 m) and large enough to accommodate a copy of the cabinet wiring diagram, controller manual, and documentation for other accessories.

5. *Wiring*. All wiring within the cabinet shall be neat and routed such that opening and closing the door or raising and lowering the back panel will not twist or crimp the wiring. All wiring harnesses shall be either braided, sheathed in nylon mesh sleeving, or made of PVC or polyethylene insulated jacketed cable. Wiring leading to the cabinet door shall be of PVC jacketed cable only. Loop detector harnesses shall be made from jacketed cable only.

   All conductors between the main power circuit breakers and the signal power bus shall be a minimum size 10 AWG stranded copper. All conductors carrying individual signal lamp current shall be a minimum size 16 AWG stranded copper. All AC service lines shall be of sufficient size to carry the maximum current of the circuit(s) they are provided for. Minimum cabinet conductor wire size shall be 22 AWG stranded copper. All wiring and insulation shall be rated for 600 volts or greater.

   Conductors for AC common shall be white. Conductors for equipment grounding shall be green. All other conductors shall be a color different than the foregoing.

   A barrier terminal block with a minimum of three terminals and one compression fitting designed to accept up to a 4 AWG stranded wire shall be provided for connection of the AC power lines. The block shall be rated at 50 amperes and shall have binder head screw terminals. All AC wiring in the path from the terminal block to the transient surge suppression device shall be isolated and bundled separately from all other wiring in the cabinet.

   All terminals shall be permanently identified in accordance with the cabinet wiring diagram and as listed below. Where through-panel solder lugs or other suitable connectors are used, both sides of the panel shall have the terminals properly identified. Identification shall be permanently attached and as close to the terminal strip as possible and shall not be affixed to any part which is easily removable from the terminal block panel.

   A. Each controller input and output function shall be distinctly identified with no obstructions, at each terminal point in the cabinet, with both a number and the function designation. The same identification must be used consistently on the cabinet wiring diagrams.

   B. Each load switch socket shall be identified by number. No cabinet equipment, including the load switches themselves, may obstruct these identifications.

   C. Each flash transfer base and power relay base shall be properly identified with no possible obstructions.

   D. Each harness within the cabinet shall be distinctly identified by function on the connector end.

   E. The flasher socket shall be distinctly identified with no possible obstruction.

   F. All other sockets needed within the cabinet to fulfill the minimum requirements of the plans, or attachments thereof, shall be distinctly identified.

All NEMA controller unit and conflict monitor connector pinouts, except for the loadswitch inputs to the conflict monitor, shall be made available on binder head screw terminals on the back panel.

The controller unit harness (A, B, and/or C plugs) shall be long enough to reach any point 15 inches (0.40 m) above the timer shelf. The conflict monitor harness and any required auxiliary harness shall reach 24 inches (0.60 m) from the conflict monitor shelf.

Copper ground buses shall be provided for both the power supply neutral (common) and chassis ground. The AC neutral and chassis ground buses shall be jumpered together with a minimum 10 AWG wire. The logic ground shall be isolated from the AC neutral and terminated on a logic ground bus designed to accept 20 number 20 AWG stranded wires.

The circuit breakers shall be equipped with solderless connectors and installed on the right side wall (facing the cabinet) or lower right hand side of the back panel inside the cabinet. The breakers shall be easily accessible. The breakers shall be positioned so that the rating markings are visible.

The above breakers are in addition to any auxiliary fuses which may be furnished with the controller to protect component parts, such as transformers, etc.

The load side of the main circuit breaker shall be protected by a lightning surge suppressor, such as the EDCO ACP-340, or an approved equal. The suppressor ground connection shall be connected to the cabinet. The suppressor shall be connected to the line filter as recommended by the manufacturer. Number 10 AWG or larger wire shall be used for connections to the suppressor, line filter and load switch bus.

A relampable fluorescent light, with switch, shall be installed in the cabinet. This light shall turn on when the cabinet door is opened, and turn off when the cabinet door is closed.

Transient suppression devices shall be placed on the coil side of all relays in the cabinet. DC relay coils shall have, as a minimum, a reversed biased diode across the coil. AC relays shall have MOV's or equivalent suppression across their coils. RC networks are acceptable. One suppression device shall be supplied for each relay.

Except where soldered, all wires shall be provided with lugs or other approved fittings for attachment to binding posts. Insulation parts and wire insulation shall be insulated for a minimum of 600 volts.

The outgoing traffic control signal circuits shall be of the same polarity as the line side of the power source.

A switch shall be provided on the inside face of the cabinet door that shall be labeled "Auto-Flash." When the switch is in the "Flash" position, call for flashing operation shall not remove the power from the controller unit, in order to allow the controller to operate in a normal fashion, while the intersection is in flash. When the switch is in the "Auto" position, the operation shall be in a fully automatic mode with the signals on. A switch shall be provided near the "Auto-Flash" switch to cause the controller unit, and any auxiliary equipment, to stop timing. It shall be labeled "Stop Timing". This "Stop Timing" switch shall have three positions. The top position shall be labeled " Automatic Operation", the middle position shall be labeled "Stop Time Off", and the bottom position shall be labeled "Stop Time On." A controller power on/off switch shall also be provided.

The cabinet shall be wired so that activation of the conflict monitor will cause the controller unit, and any auxiliary equipment, to stop timing. Conflict and manual flash shall be wired for all red.

The red enable and remote reset from the conflict monitor shall be terminated on the face of the back panel.

(c) **Conflict Monitor.** The conflict monitor shall meet the standards of NEMA Publication No. TS-1. The number of channels shall be as required on the plans. If the phasing on the plans calls for additional channels, they shall be provided and the cost shall be included in the price bid of the controller.

(d) **Solid State Load Switch.** The solid state load switches shall meet the requirements set forth in Section 5 of the NEMA Specification No. TS-1, and shall be "Triple-Signal Load Switch" type. The load switches shall be all solid state and an indicator light for each circuit shall be provided in each load switch. The indicator light shall be on when a "true" input to the load switch is present.

(e) **Two Circuit Solid State Flasher.** The flasher shall meet the electrical and physical characteristics described in Section 8 of the NEMA Standards Publication TS-1. The two circuit flasher shall be of solid state design and contain no electromechanical devices. The voltage range shall be 95 to 135 volts AC. The nominal voltage shall be 120 volts AC. The operating frequency range shall be 60 HZ +/- 3.0 HZ. The two circuit solid state flasher shall be designed to operate as specified at any ambient temperature range from -30°F to160°F (-34° C to 74° C). The flasher shall be so constructed that each component may be readily replaced if needed. The flasher shall be a Type III (dual circuit rated at 15 amperes per circuit) unit.

(f) **Documentation.** Each cabinet shall be provided with the following documentation:

1. Three complete, accurate, and fully legible cabinet wiring diagrams.
2. One manual for the controller, conflict monitor, load switch, flasher, and all detector units.

825.04. CONSTRUCTION METHODS.

Construction Methods Install the vehicle-actuated solid state traffic signal controller at the location shown on the Plans in accordance with the manufacturers requirements and Specifications.

825.05. METHOD OF MEASUREMENT.

Traffic vehicle actuated solid state digital traffic signal controller units with auxiliary equipment including cabinet and installation will be measured by the unit, complete in place.

825.06. BASIS OF PAYMENT.

Traffic vehicle actuated solid state digital traffic signal controller assemblies, measured as provided above, will be paid for at the contract unit price as follows:

TRAFFIC SIGNAL CONTROLLER ASSEMBLY..... .....EACH

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.