MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION TYPE TRAFFIC SIGNAL CABINET

a. Description. This work consists of furnishing, delivering, and installing a traffic signal cabinet, *NEMA* type.

This work includes furnishing and delivering the cabinet to the maintaining agency for cabinet setup. This work includes transporting the cabinet from the maintaining agency to the job site for installation. This work includes installation of the cabinet, and accessories required to provide the traffic signal control operations as shown on the plans, in accordance with the *MMUTCD* and this special provision. As applicable this work includes mounting brackets and hardware, conduit risers, wiring, connectors, grounding, terminating signal wiring, and all appurtenant materials required to ensure a complete installation.

b. Material. Provide materials meeting the requirements in sections 918 and 921 of the Standard Specifications for Construction and this special provision.

1. Cabinet. This special provision defines the minimum acceptable requirements for a series of cabinets that differ in size, to house the controller unit (CU) and related devices. Provide the base mounted size 6-ITS cabinet unless the plans indicate otherwise.

A. Cabinet Dimensions. Outside dimensions are as shown in Table 1. These dimensions are outside dimensions exclusive of hinges, handles, overhang(s), vent housing, and adapters. Cabinet heights are measured to the lowest point of the top surface of the cabinet. Ensure the combined overhangs of the four sides of the cabinet does not exceed 4 inches.

Table 1: Minimum Outside Dimensions

Size	Height (inches)	Width (inches)	Depth (inches)
M36-ITS	71	36	17
6-ITS	66	44	25.5

B. Cabinet Types and Mountings.

(1) Base Mounted (6-ITS). Ensure the size 6-ITS cabinet can be constructed so that it can be mounted on a 30 inch by 48 inch foundation. Anchor bolt mounting provisions for four bolts on 40¾ inch centers (side-to-side) on 18½ inch centers (front-to-back). Include one base adaptor, 15 inches in height, with the same dimensions and bolt pattern as the cabinet. Provide eight nuts and eight washers with each size 6-ITS cabinet.

(2) Pole Mounted/Base Mounted (M36-ITS). Ensure cabinets intended for side of pole mounting are provided with any necessary adapter, inclusive of steel banding, to permit mounting to a 4½ inch or larger diameter pole. Ensure the adapter accommodates lag bolts up to 3/8 inch and steel banding up to 1 inch wide. Ensure mounting points are provided at or near the top and bottom of the cabinet. Ensure the adapter has provisions for two holes spaced horizontally, which will have a center-to-center distance of 3½ inches. Furnish cabinets without conduit holes. In addition, ensure the cabinet is provided with a removable bottom to enable it to be pole or base mounted.

(3) Anchor Bolts. Provide anchor bolts for base mounted cabinets which are 3/4 inch in diameter by 42 inches long which includes a 90-degree bend with a 3-inch leg. Ensure the long leg is threaded for at least 3 inches with a 3/4 inch Unified Coarse Thread (UNC) -10 thread. Ensure anchor bolts are steel with a hot-dipped galvanize. Per standard *AISI 300 Series*.

C. Materials. Construct the traffic control cabinet of aluminum. Ensure the aluminum material is a minimum of 1/8 inch alloy sheet, *ASTM B209*, *5052-H32* or equivalent.

D. Finish and Surface Preparation. Paint and prepare cabinets as specified herein.

(1) Prepare the surface of the cabinet to Aluminum SSPC or approved equal prior to painting, to avoid paint peeling.

(2) Paint the interior surface white. Ensure the interior of the controller cabinet is finished with a durable two coat white paint having a total dry film thickness of not less than 0.75 mils.

(3) Ensure the exterior of the controller cabinet and all mounting attachments are finished with a durable and weather-resistant protective coating having a total dry film thickness of not less than 1.5 mils. Ensure the final coat is aluminum in color, gives complete coverage, and is at least 0.75 mil in thickness.

(4) Repaint any scratched or damaged surface area. Ensure the final repair coat is aluminum in color, yields complete coverage, and is at least 0.75 mil in thickness.

E. Top Surface Construction. Ensure the cabinet is manufactured to prevent the accumulation of water on its top surface.

F. Doors.

(1) Main Cabinet Door. Ensure the cabinet has a main door which permits access to all equipment within the cabinet. Ensure doors are hinged on the right side of the cabinet as viewed from the outside facing the cabinet door opening. Ensure the door has a handle of one piece construction and swings away from the locking mechanism.

(2) Hinges. Ensure all cabinet doors incorporate a piano type hinge utilizing stainless steel hinge pins.

(3) Door Stop. Ensure the cabinet door is provided with a door stop which holds the door open at 90 degrees, 135 degrees and at 180 degrees (±20 degrees at each

stop).

(4) Latches and Locking Mechanism.

(a) Ensure all cabinets incorporate a main door lock, Corbin No. 15481RS, Pelco (Type II) SM-1025 or equivalent, constructed of nonferrous or stainless materials, which operates with a Traffic Industry conventional #2 key, Corbin No. 1R6380 or Pelco (Type II) SM-0198-2 or equivalent. Ensure a minimum of two keys are included for the main door of each cabinet.

(b) Ensure the cabinet door(s) is provided with a three-point latch. Ensure the top and bottom has rollers to secure the door in a closed position.

(c) When in the locked position, ensure the lock prevents the movement of the three-point latching mechanism.

(d) Ensure the cabinets provide with a means of externally padlocking the latching mechanism. Ensure a minimum of 3/8 inch diameter lock shackle is accommodated.

(5) Door Opening. Ensure the main door opening of all cabinets is at least 80 percent of the area of the cabinet side which the door closes, exclusive of the area of plenums.

(6) Switch Compartment.

(a) Mount a hinged switch compartment door to the outside of the main cabinet door. Ensure the door permits access to a switch panel, but does not allow access to exposed electrical terminals or other equipment within the cabinet.

(b) Ensure the switch compartment with the door closed has minimum internal dimensions of 3½ inches high, 7½ inches wide, and 2 inches deep. Additionally, ensure the volume is not less than 70 cubic inches.

(c) Ensure switch compartment doors are equipped with a lock, which can be operated by a police key, Corbin Type Blank 04266 or Pelco Type SM-0200 long keys, or equivalent. Ensure a minimum of two keys are included for the switch compartment of each cabinet.

(7) Intelligent Transportation System (ITS) Compartment.

(a) M36-ITS and 6-ITS cabinets must include a hinged compartment door mounted to the outside front of the cabinet, above the main door. The door must permit access to shelf mounted ITS devices and electrical power components to power these devices.

(b) To allow for the ITS and power components, ensure the ITS compartment door has a minimum opening size of 8 inches high by 27 inches wide for the M36-ITS cabinet and 8 inches high by 41 inches wide for the 6-ITS cabinet. The depth of the compartment will be the full depth of the cabinet.

(c) The ITS compartment door is to be equipped with a Type 2 lock, cut for the Traffic Industry standard #1 key. Include a minimum of two keys for the ITS compartment.

(d) Make accommodation to allow free air movement from the ITS compartment to the controller compartment.

(e) The ITS compartment will include U-channels mounted to the sides of the compartment for future mounting of shelves and/or Deutsches Institut für Normung (DIN) rail(s). Four U-channels, two on each side, must run vertically up the entire height of the compartment. Two additional U-channels must run horizontally across the entire back of the compartment.

(f) Run flexible 1½ inch innerduct from the dedicated ITS conduit at the bottom of the cabinet to the ITS compartment. Run the flexible innerduct up the back-left corner inside the main compartment of the cabinet into the ITS compartment. Install the flexible innerduct in such a way that wires and cables can be run into the ITS compartment from outside the cabinet without accessing the main compartment of the cabinet.

(g) Provide passageway for 1½ inch innerduct by cutting rear shelf corners and rear corners of top of signal cabinet.

G. Shelves.

(1) Ensure the cabinet is provided with two shelves for supporting the control equipment.

(2) Ensure the shelves are at least 10 inches in depth. Shelf height must leave a minimum of 2 inches of clear space between the top of the CU and the bottom horizontal surface of the shelf without blocking access to the back panel. Ensure the distance between the back of the shelves and the back of the cabinet does not exceed one inch or provide a one inch upturned barrier at the rear edge of the shelf.

(3) Ensure all cabinets have a provision for positioning shelves to within 12 inches of the bottom of the cabinet and to within 6 inches of the top of the cabinet in increments not more than 1/2 inch.

(4) Ensure the face of the upper shelf comes complete with a section of polyvinyl chloride (PVC) slotted, 1 inch by 1.5 inches wiring finger duct installed across the face, leaving 4 inches of shelf exposed on both sides.

H. Cabinet Risers.

(1) Ensure the 6-ITS are provided with a 15 inch high cabinet riser.

(2) Ensure the riser matches the mounting base of the cabinet and is provided with anchor bolt holes on the top and bottom of the risers.

(3) Ensure the risers come in two parts for ease of assembly.

I. Ventilation System. Ensure all cabinets incorporate a ventilation system to provide for the circulation of external air through the enclosure to remove excess heat, fumes, or vapors. Ensure each cabinet is equipped with an electric fan with a capacity of at least 100 cubic feet of air per minute.

(1) Fan. Ensure the fan on all aluminum door cabinets is installed so that it operates in the filtered incoming air stream so as not to create a negative pressure within the cabinet relative to its outside environment. Ensure all fans are equipped with a guard which inhibits a user from making contact with the blades of the fan.

(2) Fan Controls.

(a) Ensure all cabinets equipped with a fan has a device to control the operation of the fan.

(b) Ensure the device switch-on point is manually adjustable at least in the range from 80 degrees Fahrenheit (F) to 120 degrees F.

(c) Ensure the device has a differential between its switch-on point and its switch-off point. Ensure this differential is not greater than 25 degrees F.

(d) Ensure the device is placed in the inside of the top of the cabinet not lower than 6 inches from the top of the cabinet.

(3) Filter. Ensure the cabinet is equipped with a device to filter the incoming air. Ensure the cabinets are provided with louvered vents in the main door with a replaceable air filter having a width of 16 inches, a height of 12 inches, and a thickness of 1 inch.

J. Terminal Facility. This special provision defines the minimum acceptable requirements for terminal facilities to interconnect the related devices within a traffic control cabinet.

(1) Mechanical Construction. Ensure the terminal facility is in accordance with the following mechanical requirements.

(a) Terminal Identification.

(i) Ensure all terminals are permanently identified in accordance with the cabinet wiring diagram. Ensure where through-panel terminal blocks are used, both sides of the panel have the terminals properly identified with the terminal position number.

(ii) Ensure identification is permanently attached as close as possible to the terminal strip and is not affixed to any part which is easily removable from the terminal block panel.

(iii) Ensure each input or output terminated on a terminal block is identified on the front of the panel by position number and function terminology (e.g., Ph 1 Red, Ph 2 Hold, etc.).

(iv) Ensure the same identification is used consistently on the cabinet wiring diagram.

(b) Component Identification. Ensure all components which make up the basic terminal facility are permanently identified in accordance with the cabinet wiring diagram. The following components are considered part of the basic terminal facility:

(i) Load Switch Sockets;

(ii) Flash Transfer Relay Sockets;

(iii) Flasher Socket;

(iv) Main and Auxiliary Circuit Breakers;

(v) Radio Interference Suppressor and Surge Protector;

(vi) Solid State Signal Power Relay; and

(vii) Power Terminal Bus Bars.

Ensure where through-panel components are used, both sides of the panel have the components properly identified by relative symbols (e.g., FRI, LS1, etc.).

Ensure identification is permanently attached and as close to the component as possible and is not affixed to any part which is easily removable from the panel.

Ensure each component is identified on the front of the panel by symbol and function terminology (e.g., LF1 Filter, BR1 Signal Bus, etc.).

(c) Load Switch and Flasher Support.

(i) Design and construct load switch and flasher bases to receive all such devices which may be manufactured to the maximum size requirements permitted under the *NEMA Standards Publication*.

(ii) Ensure all support(s) are provided so that, at a minimum, it(they) is(are) supporting the flasher and load switch of the maximum size at some point(s) between 3 inches and 7 inches from the panel.

(iii) Ensure at least 90 percent of the area beneath the load switch or flasher is open to allow for the free flow of air across the load switches or flasher. Ensure there is no obstruction within 1 inch above or below the units within the open area.

(d) Load Switch, Flasher, and Flasher Transfer Positions.

(i) Ensure wired load switch, flasher, and flash transfer relay sockets are provided in the quantities listed in Table 2.

Table 2: Load Switch, Flasher, and Flash Transfer Socket Relay Quantities

Configuration	Load Switch	Flasher	Flash Transfer
A2	8	1	4
A5	12	1	6
A16	16	1	6

(ii) Wire the flasher socket for a Type 3 solid state flasher in accordance with *Section 8 of NEMA Standards Publication*.

(iii) Ensure conflict flashing of load bay output numbers for *NEMA* configured main street approaches are placed on one flasher circuit, and the load bay output numbers for *NEMA* configured side street approaches are placed on the other flasher circuit Ensure it is possible to flash either the amber or red indication on any load switch outputs. Ensure it is possible to easily change the flash indication from the front side of the panel using simple tools without the need to unsolder or re-solder connections.

(iv) Wire the load switch sockets for triple-signal load switches in accordance with *Section 5 of NEMA Standards Publication TS 2* for Type 2 CUs. Ensure all load switch driver outputs coming out of the CU are on separate terminal points from the respective inputs to the load switches. Ensure these separate termination points are bussed for normal operation. Ensure all load switch outputs are on separate points from the respective inputs to the malfunction management unit (MMU) inputs. Ensure these separate points are bussed for normal operation.

(v) Orient load switch sockets for the A2 configuration in a single row of eight. Ensure socket positions one thru four are for phase one thru four vehicles, respectively. Ensure socket positions five thru eight are for phases one thru four pedestrians, respectively.

(vi) Orient load switch sockets for the A5 configuration in a single row of 12. Ensure socket positions one thru eight are for phase one thru eight vehicles, respectively. Ensure socket positions 9 thru 12 are for phases 2, 4, 6, and 8 pedestrians, respectively.

(vii) Orient load switch sockets for the A16 configuration in two rows of eight positions each. Ensure the top row includes socket positions one thru eight and is for phase one thru eight vehicles respectively. Ensure the lower row includes socket positions 9, 10, 11, and 12 for overlaps A thru D, respectively, and are located below socket positions 1, 3, 5, and 7 respectively. Ensure socket positions 13, 14, 15, and 16 in the lower row are below and to the right of socket position 8, and is for pedestrian phases 2, 4, 6, and 8 respectively.

(viii) Ensure the back panel/load bay is hinged at the bottom corners to allow a 90 degree panel fold down.

(e) Terminal Blocks. Ensure terminal blocks have mechanical characteristics

to properly support the wiring connected without warping the terminal block. Ensure all materials including screws and threaded portions used in terminals and terminal blocks are stainless steel. Ensure the maximum number of wire terminations or metal jumpers used in any combination under a single screw does not exceed two in number.

(i) Field Terminal Blocks. Include field terminal blocks for all inputs and outputs for a fully expanded CU. Ensure these blocks are either single terminal type with through-panel connection on the rear side of the mounting panel or double binder head screw terminals. Ensure either type of terminal block uses the correct ampacity for the application. Minimum acceptable ratings are 30 ampere (A), 300 volt (V), with 10 - 32 binder head screws.

(ii) Control Terminal Blocks. Include control terminal blocks for inputs and outputs of the CU, MMU, flash transfer relays, load switches, etc. Ensure these blocks are either single terminal type with through-panel connections or double binder head screw terminals. Ensure either type of terminal block uses the correct ampacity for the application. Minimum acceptable ratings are 15A, 250V, with 6-32 x 1/4-inch pan or binder screws. Ensure the maximum number of wire terminations or metal jumpers used in any combination under a single screw does not exceed two in number.

Ensure the control terminal block wiring provides groupings of functions based on probable interconnect (bussing) for normal operation rather than based on the source of the wiring (e.g., CU, MMU, etc.).

(iii) Detector Terminal Blocks. Include detector terminal blocks for loop and push button inputs. Ensure these blocks are either single terminal type with through-panel connections or double binder head screw terminals. Ensure either terminal block is of the correct ampacity for the application. Minimum acceptable ratings are 20A, 250V with 8 - 32 pan or binder screws.

(f) CU and MMU Harnesses.

(i) Ensure the CU and MMU harnesses are neatly arranged and provided with the flexibility for the connectors to reach at least 40 inches from the top of the terminal block panel which must be mounted directly below the CU shelf. Ensure the harness connectors do not have any sharp edges and the stress relief attachment screws do not extend greater than 1/4 inch beyond the stress relief.

(ii) Ensure terminal positions are provided, completely wired and neatly arranged, providing access to all inputs and outputs listed in the CU specification. Ensure all *NEMA Standards Publication* functions of the CU for the configuration selected are terminated, except those designated by *NEMA* as spares, reserved, no connection, and manufacturer's use need not be installed in the harness.

(iii) Ensure terminal positions are provided, completely wired and neatly arranged, providing access to inputs and outputs in the MMU. Ensure all MMU input is terminated. Ensure provisions are made to terminate any unused red

monitoring inputs. Ensure type select and port one disable inputs are terminated.

(iv) Provide a D connector for connection to the CU. Provide a connector of the style for the controller approved for the project. Attach the connector terminal strip via channel nuts to the upper left side of the cabinet.

(v) Ensure the MMU harness is configured for a 16 channel MMU operating in the type 12 mode. Ensure the MMU harness is configured as specified in Table 3.

Table 3: MMU Harness Configuration

Configuration	Load Switch	MMU
A2	8	12 Channel
A5	12	12 Channel
A16	16	12 Channel

(g) Power Distribution. Supply the following equipment as part of the power distribution panel:

(i) Main Circuit Breaker;

(ii) Six Auxiliary Circuit Breakers;

(iii) Solid State Signal Power Relay;

(iv) Primary and Secondary Surge Protector;

(v) Neutral Bus Bar;

(vi) Equipment Ground Bus Bar;

(vii) AC Power (Filtered) Terminal Strip;

(viii) AC Power (Unfiltered) Terminal Strip.

(h) Supply the following equipment as part of the ITS compartment power panel:

(i) Three Auxiliary Circuit Breakers;

(ii) Neutral Bus Bar;

(iii) Equipment Ground Bus Bar.

(2) Electrical Requirements. Ensure the terminal facility conforms to the following electrical requirements:

(a) Power Distribution. Ensure the terminal facility operates properly when

supplied with single-phase alternating current (AC) power [95-135V, 57-63 hertz (Hz)] when non-ITS cabinets and 240V when an ITS type cabinet. Ensure all breakers and grounding devices are wired in accordance with the *NEC* and the *Michigan Electrical Code*.

(i) Circuit Breakers. Ensure provisions are made for mounting and wiring up to nine circuit breakers in the terminal facility. Ensure a quantity of seven circuit breakers are provided with ampacities as specified in Table 4.

Table 4: Circuit Breaker Ampacity (in A)

Configuration	Main	Vehicle Load Switch	Pedestrian Load Switch	Flasher	Miscellaneous	Channel Reds	Illuminated Sign
A2	30	10	10	10	10	10	20
A5	30	10	10	10	10	10	20
A16	30	10	10	10	10	10	20

The 6-ITS cabinets will include an additional 30A circuit breaker mounted on the main cabinet power panel, utilizing a single phase of the AC power to power the ITS compartment devices. Two 15A and one 10A circuit breakers will be provided in the ITS compartment, wired to the load side of the 30A breaker.

Ensure the main circuit breaker is wired to protect the entire facility and is identified as the “MAIN” breaker. Ensure the Vehicle Load Switch breaker and the Pedestrian Load Switch breaker are fed by the load side of the bus relay and provides power to the vehicle and pedestrian load switches, respectively. Ensure the Flasher breaker has the flasher connected to its load side. Ensure the miscellaneous breaker has the cabinet fan, light, and door mounted duplex receptacle connected to its load side. Ensure the Channel Red breaker is connected to the input to the MMU for the Red enable and cabinet control relay coils. Ensure the Illuminated Sign breaker is available to power auxiliary devices such as illuminated signs. Ensure the breaker for the ITS compartment (if used) will be fed by a separate phase connected to the power disconnect. Ensure the circuit breakers are capable of manual operation with markings to indicate rating and whether it is in the open or closed position. Ensure Square D series QOB circuit breakers are used and mounted on QON3B triple position breaker blocks.

Ensure a four pole fuse holder with screw terminals for connecting individual illuminated sign loads is provided and wired to the load side of Illuminated Sign breaker. Include a 5A time delay fuse with each holder.

(ii) Cabinet Surge Protection. Ensure the power panel has devices to provide both primary and secondary surge protection devices. Ensure the Line In, Neutral In and Ground leads of the primary device are to be kept as short as possible (18 inches maximum), with no sharp bends and must not be bundled with other conductors.

Ensure the primary surge protection device (SPD) has two separate hot legs. For the non-ITS cabinets, ensure both legs of the SPD are connected to the

load side of the main circuit breaker. Ensure for the 6-ITS cabinets, the second leg is connected to the load side of the main circuit breaker for the ITS compartment. Ensure the primary SPD is connected in parallel to the load and have a surge capacity of 160 kiloamperes (kA) per phase or greater. Ensure the let through voltage measured 6 inches outside the unit does not exceed 430V for 3kA 8/20 microseconds(u/s) pulse or 650V for 10kA 8/20 u/s pulse. Ensure modes protected are Line to Ground, Line to Neutral, Line to Line and Neutral to Ground. Ensure the SPD provides Green light emitting diode (LED) indications that protection is operational and Red LED indications that a fault has occurred. Ensure in addition, an audible alarm sounds indicating a fault has occurred. Ensure there is a set of normally open and normally closed contacts available for remote monitoring of the SPD. Ensure the SPD is no larger than 9.3 inches wide by 3 inches high by 4.93 inches deep. Ensure the SPD is mounted on the lower right hand side of the cabinet and easily accessible for replacement.

Ensure the secondary SPD is connected to the load side of the main circuit breaker and its output is used to supply AC power the CU, MMU, and cabinet electronics power strip. Ensure the surge current capacity is 50kA or greater, with the unit connected in series to the load. Ensure the secondary SPD is a 5-stage hybrid design with integrated filter with series load current of 12A. Ensure the let through voltage measured 6 inches outside the unit does not exceed 260V for 2kA 8/20 u/s pulse or 300V for 3kA 8/20 u/s pulse. Ensure modes protected are Line to Ground, Line to Neutral, and Neutral to Ground.

Ensure a gas tube device is installed on the load side of the main circuit breaker. Ensure it is possible to replace this device without interrupting power to the rest of the terminal facility. The 6-ITS cabinets must have a second gas tube device installed on the load side of the main circuit breaker feeding the ITS compartment. For the ITS cabinets, ensure that the ITS compartment includes a switched, surge protected, outlet strip. This outlet strip is to provide a minimum 3,300 joule suppression rating and is wired to the load side of one of the 15A ITS compartment breakers. Ensure the outlet strip is mounted on the panel on the right side of the cabinet.

(iii) Solid State Signal Power Relay. Ensure the terminal facility includes a single-pole, single-throw (SPST)-no signal power relay wired to provide power from the main circuit breaker and radio frequency interference (RFI) filter to the AC signal power bus bar and load switches. Ensure the solid-state relay is energized to provide power to the signal bus and have ampacity of 75A. Ensure it provides zero voltage switching from 47 – 63Hz. Mount the signal power relay on a panel on the lower right side of the controller cabinet and easily accessible for replacement.

(iv) AC-Common Bus Bar. Terminate the AC-common (Neutral) on a solid metallic multi-terminal bus bar that will accept #4 - #16 American Wire Gage (AWG) copper conductors. Insulate this bus bar from the cabinet. Run separate wires from this bus bar to each unit or group of similar units in the terminal facility which requires AC-common connection. Ensure only one conductor is allowed in each termination position. Ensure a minimum of 24 open termination positions are available for field wiring common return

connections.

(v) Equipment Ground Bus Bar. Terminate the equipment ground on a solid metallic multi-terminal bus bar that will accept #4 - #16 AWG copper conductors. Connect this bus bar to the cabinet. Allow only one conductor in each termination position. Ensure a minimum of 24 open termination positions are available for field wiring ground connections.

Run separate wires from this bus bar to each unit or group of similar units in the terminal facility which requires equipment ground connection.

(vi) In addition to the three breakers and surge protected outlet strip, ensure the upper ITS compartment includes: a ground fault interrupter (GFI) outlet wired to the load side of one of the 15A breakers, a minimum 6 position ground bus, LED lighting mounted above the air plenum above the door powered via a door switch and 10A breaker, and a minimum 12-inch-long piece of DIN rail mounted across the channels on the back of the cabinet.

(b) Conductors. Ensure all conductors used in the terminal facility wiring are #22 AWG, or larger, with a minimum of 19 strands. Ensure conductors terminated on the AC-common bus bar and safety ground bus bar are tinned and a minimum size of #16 AWG. Ensure the insulation has a minimum thickness of 10 mils and is nylon jacketed polyvinyl chloride or is irradiated cross-link polyvinyl chloride. Ensure conductors #8 AWG are *UL* Type THHN.

Ensure all conductors used in the terminal facility wiring are in accordance with the following color-code requirements:

(i) Ensure the AC-neutral conductor of a circuit is a continuous white color.

(ii) Ensure the equipment ground conductor of a circuit is a continuous green color or a continuous white color with one or more green stripes.

(iii) Ensure the AC ungrounded power conductor of a circuit is a color other than white or green.

(iv) Ensure the low-level direct current (DC) (+24 or less) conductor of a circuit is a continuous blue color.

(v) Ensure other conductors, not conforming to one of the above, are any continuous color not defined above.

(c) Wiring (Power Distribution within the Facility).

(i) Ensure all terminal facility wiring is neat, firm, and routed, where practical, to minimize crosstalk and electrical interference. Do not use printed circuit boards to eliminate or reduce facility wiring. Do not use adhesive-backed means to support any wiring.

(ii) Ensure connectorized multi conductor wiring are covered in non-split type looming material.

(iii) Ensure all terminal facility conductors are of sufficient size to carry the maximum current of the circuit or circuits they are provided for. Ensure they are sized based on the ampacity ratings per Table 5.

Table 5: Terminal Facility Conductor Size

AWG Wire Size	Ampacity Rating
#22	5A
#16	10A
#14	15A
#12	20A
#10	30A
# 8	50A
# 6	70A

(iii) Ensure the conductor feeding power from the main circuit breaker to the auxiliary breakers, solid state signal power relay, primary and secondary SPD terminal blocks, and AC signal power bus bar has an ampacity of 30A.

(iv) Ensure the conductor feeding power to the flasher socket has, as a minimum, an ampacity of 10A.

(v) Ensure the conductor feeding power to the signal power bus bar to each load switch socket has an ampacity of 10A.

(vi) Ensure the conductors feeding power from the load switch to the field signal terminals has an ampacity of 10A.

(vii) Ensure the conductors feeding power from the flasher socket to the flash transfer relay sockets, which feed flashing power to same, has an ampacity of 10A. The remaining wires to and from the flash transfer relay socket, which are in the circuit between the load switch socket and the field signal terminals, are covered in the previous paragraph.

(d) Control Circuits.

(i) Flash Transfer Control. Ensure the control circuit to the flash transfer relay sockets can provide flashing operation when the MMU or optional auxiliary equipment call for flash (e.g., police panel flash switch and maintenance panel). Ensure the flash transfer control also conforms to the following:

Ensure the flash transfer relay socket is wired so the coil of the relay(s) must be de-energized for flashing operation. Ensure the flash transfer relay sockets are near the load switches, flasher, and field signal terminals.

(ii) MMU Control. Ensure the MMU is wired to provide flashing operation when the fault relay de-energizes or if the MMU is disconnected. Ensure it also provides "Stop Time" to the CU when the fault relay de-energizes. Ensure the

MMU is wired to provide an "External Start" signal to the CU upon the application of AC power to the MMU following a power interruption or upon initial turn-on.

(iii) Detector Rack. All cabinets must include a 20-channel detector rack that meets *NEMA TS2- Section 5 specifications*. Ensure the detector rack accommodates 16 channels of vehicle detection and an additional 4 channels of pedestrian detection push button isolation. Ensure the bus interface unit (BIU) slot is in the first (furthest to the left) position in the detector rack. Ensure the 16 channels of vehicle detection are located immediately to the right of the BIU. Ensure the four channels of pedestrian detection are in the last (furthest to the right) slot positions. Ensure a harness that is compatible with the pushbutton control card is installed from pedestrian signal field terminals to the detector rack. Ensure each cabinet includes one power supply for the detector rack that meets the *NEMA TS2-* specification for power supplies.

(3) Field Wire Terminal Locations. Ensure the terminal facility provides field wire terminals located in accordance with the following requirements:

(a) AC Service Hookup. Terminate incoming AC power service on the right side of the cabinet on the power distribution panel. Terminate the incoming AC power service using listed pressure connectors capable of accepting a #4 AWG conductor for the grounded, ungrounded, and equipment grounding conductors. Terminate the ungrounded conductor directly to the main circuit breaker. Terminate the neutral and equipment ground conductors directly to their respective bus bars. Ensure this service hookup meets *NEC* code, and the *Michigan Electrical Code*.

(b) Signal Hookup. Terminate signal wires on terminal blocks on the back of the cabinet at least 3 inches but not over 6 inches from the bottom of the cabinet. Locate the field terminal block for signal circuits a minimum of 4 inches below the load switches and angled up 30 to 45 degrees from vertical for ease of access. Ensure signal terminals are directly accessible from the front of the cabinet. Provide one terminal for each load switch output. Ensure each field terminal for phase vehicle and phase pedestrian signals, includes a SLU-35 or equivalent pressure connector that will allow multiple field conductors to be attached to a single output terminal. Ensure it is possible to terminate a minimum of 16 #14 AWG neutral leads on the signal neutral bar.

(c) Detector Panel. Terminate vehicle loop and pedestrian pushbutton inputs on terminal blocks on the left side of the cabinet at least 3 inches from the bottom of the cabinet. Provide a minimum of three terminals for each vehicle detector and four terminals for each pedestrian detector. Ensure the terminal block meets the specifications of the detector terminal blocks. Ensure the detector panel is wired completely to the detector rack, providing 20 channels total.

(4) Auxiliary Equipment.

(a) Ensure the terminal facility includes provisions for the following equipment in a panel accessible from a police door on the front of the cabinet.

(i) Signals On-Off Switch. Ensure a signals on-off switch is included, installed, and wired.

Ensure the switch and wiring energizes or de-energizes the solid-state signal power relay. Ensure the AC signal power is not routed through this switch. Label the switch "Signal-Off". Ensure when in the “Off” position, all signal field terminals are de-energized and the Red Enable input to the MMU is inactive.

(ii) Flash Normal Switch. Ensure a flash-normal switch is included.

Ensure when in the Flash position, the flash transfer relays and solid state signal power relay is de-energized, and power is removed from the MMU and CU, resulting in flash being displayed to traffic. Ensure neither AC signal power nor flashing power is routed through this switch. Ensure the switch is labeled "flash-normal".

Ensure when the switch is returned to the “Normal” position, the signals return to the initialization phase and begin cycling.

Ensure operation of the signal-off switch overrides this switch. That is, when in the "Off" position, the signal-off switch prevents flashing operation as called for by all flash control circuits.

(iii) Manual Control Cord and Switch. Install a manual control cord and auto-hand switch and wired in the police panel of the cabinet.

Ensure the switch and wiring energizes the "manual control enable" input to the CU and connects the manual control cord to the "interval advance" input to the CU. Label the switch "auto-hand".

(b) Maintenance Panel Options.

(i) Detector Test Switches. Provide a detector test push-button switch for each vehicle and pedestrian detector circuit in a panel on the inside of the front cabinet door. The A2 configuration requires eight test push-buttons for phases one thru four vehicle and pedestrian inputs. The A5 and A16 configurations require 12 test push-buttons for phases 1 thru 8 vehicle inputs and phases 2, 4, 6, and 8 pedestrian inputs.

Ensure the switch and wiring places an actuation for the respective vehicle or pedestrian phase when pushed. Label the switch(s) "call switch" and the phase # as well as whether it is vehicle or pedestrian (e.g., Ph 1 Veh, Ph 1 Ped, etc.).

(ii) Stop Time Switch. Provide a stop time switch in a panel on the inside of the front cabinet door. Ensure the switch and wiring provides three modes of operation which are:

1) Normal. Provides "Stop time" to the CU as required by the MMU.

2) Run. Prevents "Stop time" from being applied to the CU from other

devices.

3) Stop. Applies "Stop time" to the CU. Ensure this switch is labeled "stop-run-normal".

(iii) Flash-Normal Switch. Provide a flash-normal switch in a panel on the inside of the front cabinet door.

Ensure the switch and wiring provides flashing operation as defined for police panel flash-normal switch except that it does not terminate power to the CU. Ensure provisions are provided so that this flash-normal switch operates as a CU power switch by removing a control terminal link. Label this switch "flash-normal".

(iv) Duplex Receptacle. Provide a duplex receptacle of a three-wire GFI type in a panel on the inside of the front cabinet door.

For the M36-ITS and 6-ITS cabinets provide a duplex receptacle of a three-wire GFI type in the ITS compartment on the right side, towards the front. Wire the receptacle to one of the 15A circuit breakers in the ITS compartment.

(c) Miscellaneous Options.

(i) Cabinet Forced Air Heater. Provide a forced air heater for all cabinets, rated with at least 100 watt (W) for the M36-ITS and 6-ITS cabinet, and 200W for all other configuration cabinets, completely wired and operational. Provide a temperature and humidity level controller to operate the heater. Ensure the temperature control has an adjustable set point from 32 to 95 degrees F. Ensure the humidity control has an adjustable set point from 50 to 90 percent relative humidity. Mount the heater below the bottom shelf and offset from the cabinet walls with air forced downward. Mount the heater clear of the field wiring.

(ii) Cabinet Lights. Install two LED lighting panels with a switch in the cabinet. Provide a door switch to activate the lights when the door is opened. Install one lighting panel above the top shelf and install the second to the bottom of the lower shelf's storage drawer. Each panel must provide at least 450 lumens of light and consume no more than 15W of power.

Wire the switches and lights to the miscellaneous circuit breaker.

Install one LED light strip in the ITS compartment of M36-ITS and 6-ITS cabinets. Ensure the door switch activates the light when the door is opened.

(iii) Outlet Strips. Install a multiple outlet strip on the upper right side of the cabinet. Wire the outlet strip to the load side of the secondary SPD.

For the M36-ITS and 6-ITS cabinets install a 15A, industrial grade 3300 joule surge protected multiple outlet strip with no less than six outlets in the ITS compartment. Wire the outlet strip with resettable circuit breaker and to one of the 15A circuit breakers in the ITS compartment. Attach the outlet strip to the

bottom U-channel running horizontally across the back of the ITS compartment.

(iv) Additional Grounding. Install a #10 AWG bonding jumper from the right-hand DIN rail mounting screw in the ITS compartment to the ground bar in the ITS compartment.

Install a #10 AWG bonding jumper from both shelves in the signal cabinet to the ground bar and from the back panel in the cabinet to the ground bar.

(v) Provide an SDLC hub panel capable of bussing up to six SDLC cables in parallel. Ensure cable locking means on the ports are of the “clip” variety, and do not utilize screws to secure the cables to the panel. Install the panel in the upper right side of the cabinet to the mounting channel using screws and channel nuts designed for the purpose.

(5) Prints, Functional Data, and Parts List. Ensure the manufacturer supplies each of the following items with each cabinet:

(a) Two complete set of schematic and wiring diagrams of the cabinet and terminal facilities.

(b) Cabinet mounting diagram.

(c) Complete parts list of cabinet and accessories.

Ensure each of these items applies directly to the cabinet with which it is applied. One set is to be put in the installed cabinet, and one set is to be furnished to the maintaining agency.

2. Accessories. This special provision defines the minimum acceptable requirements for plug-in accessories for the traffic controller assembly within a traffic control cabinet.

A. Malfunction Management Unit (MMU). This subsection defines the minimum requirements for a shelf-mountable, 16 channel, Ethernet capable MMU. Ensure the MMU meets, all applicable sections of the *NEMA Standard TS-2-2003 (R2008)* for MMU2 configuration while maintaining compatibility with *NEMA TS1-1989* assemblies. Where differences occur, this special provision governs.

Provide the following monitoring functions in addition to those required by the *NEMA standard*:

(1) Dual Indication Monitoring. Ensure the MMU can detect simultaneous input combinations of active green (or walk), yellow and red inputs on the same channel. Ensure the channels enabled for dual indication monitoring are user determined. Ensure dual indication monitor is disabled when the red enable input is not active.

(2) Field Check Monitoring. Ensure when the field signal inputs states sensed by the MMU do not correspond with the data provided by the CU in the type #0 message for 10 consecutive messages, the MMU enters the fault mode and indicates the field check fail fault.

(3) Recurrent Pulse Monitoring. Ensure the MMU detects conflict, red fail, and dual indication faults that result from intermittent or flickering field signal inputs.

(4) Ensure when the MMU detects a conflict flash indication it provides an output to the “D” connector indicating an MMU/conflict flash status input.

(5) Ensure the MMU monitors an intersection with up to four approaches using the four section Flashing Yellow Arrows (FYA) movement outlined by the *National Cooperative Highway Research Program (NCHRP) Research Project 3-54* on Protected/Permissive signal displays with (FYA). Ensure the MMU provides the same fault coverage for the FYA approaches as it does for conventional movements including conflict, red fail, dual indications, and minimum clearance monitoring.

Ensure the MMU provides alternate configuration options as follows:

(a) Red Yellow Green (RYG) Only Red Fail Option. This function excludes the walk input from the red fail fault algorithm when operating the Type 12 mode.

(b) LED Signal Threshold Adjust. This function provides the capability to sense field inputs with an alternate set of voltage thresholds to better determine the state of LED signal indications. Conflict and dual indication thresholds for Green/Yellow/Red inputs are set for: No Detect is less than 15 root-mean-square voltage (Vrms). Detect is greater than 25Vrms. Red fail thresholds for Green/Yellow/Red are set for: No Detect is less than 50Vrms. Detect is greater than 70Vrms.

(c) Controller Voltage Monitor (CVM) Log Disable Option. Ensure the MMU provides a means to disable the logging of CVM faults events.

(d) Provide a 4 line by 20-character liquid-crystal display (LCD) to report MMU status, time and date, and menu navigation. Provide a separate Red, Yellow, Green LCD indicator, display for the input status of signal inputs. Provide individual icons to indicate channels involved in a fault.

(e) Provide a mode to display the Vrms of each field signal input and each cabinet control signal voltage, and the frequency of the AC line, the ambient temperature measured at the MMU.

(f) Ensure when the MMU is in the fault mode, a display screen is provided to identify all field signal inputs with field check status, and all field signal inputs with recurrent pulse status.

(g) Additional display functions include a configuration display of settings and all MMU configuration parameters; logs of previous fault, AC line, and MMU reset logs; clock set.

(h) Ensure the program card supplied with the MMU provides non-volatile memory that contains the configuration parameters for the enhanced features of the MMU, such that transferring the program card to a different MMU completely configures that MMU. Ensure the non-volatile memory device used on the

program card does not utilize any input/output (I/O) pins designated as “Reserved” by *NEMA TS-2*.

(i) Ensure a minimum of five logs are provided that graphically display all field signal states and red enable for up to 30 seconds prior to the current fault trigger event. Ensure the resolution of the display is at least 50 milliseconds. Ensure these signal sequence logs are accessible from the front panel registered jack (RJ)-45 Ethernet port with software available from the manufacture.

B. Flasher. Provide a *NEMA* two-circuit, 15A per circuit, flasher for installation in the cabinet. Ensure each flashing circuit contains zero-voltage switching, a 25A power triac, a snubber and a LED across the AC circuitry, directly indicating the AC load that is activated. Ensure the flasher conforms to a *Type 3 per Section 8* of the *NEMA Standards Publication*. Fabricate the flasher such that internal components are completely enclosed by the chassis.

C. Flash Transfer Relay. Provide flash transfer relays in the quantity of two each for the A2 configuration and six each for the A5 and A16 configurations for installation in the cabinet. Ensure the flash transfer relays conform to the following requirements:

(1) Mechanical Requirements. Enclose the relay in a transparent plastic case which protects the relay from dust, moisture, and other contamination. Ensure the case protects the user from contact with live parts and be sufficiently rugged to permit insertion and removal of the relay from its mating socket.

(2) Connector. Mount the relay on an eight-pin spade plus base and wire the socket and relay/base as follows:

Pin 1 - Coil	Pin 2 - Coil
Pin 3 - #1 Closed	Pin 4 - #2 Closed
Pin 5 - #1 Common	Pin 6 - #2 Common
Pin 7 - #1 Open	Pin 8 - #2 Open

(3) Contacts. Provide the relay with two single-pole, double-throw (form C) contact sets. Pin 8 - #2 Open each contact is rated to switch a 20A tungsten load for a minimum of 30,000 operations. The contact material must minimize welding.

(4) Coil Rating. Ensure the relay coil is rated for continuous duty from 95 to 135 volts alternating current (VAC). Ensure this rating is valid at 158 degrees F ambient temperature outside the relay case. Ensure the relay coil power consumption measures less than 10VA at 120VAC. Ensure the relay picks up by 95VAC and drops out by 50VAC, and makes the transfer within 50 milliseconds. Ensure the magnetic circuit in the relay functions without the use of diodes.

D. Load Switches. Use solid-state load switching assemblies for opening and closing signal light circuits and be jack-mounted external to the CU. Ensure each load switch provides three independent switching circuits. Ensure each of the three circuits contains a zero-voltage switching optically coupled electrically isolating the DC input circuitry from the AC output circuitry, a 25A power triac and LED indicators on both the DC input circuitry and the AC output circuitry. Provide 8 load switch assemblies (24 circuits) for the A2 configuration unit. Provide 12 load switch assemblies (36 circuits) for the A5 configuration

unit. Provide 16 load switch assemblies (48 circuits) for the A16 configuration unit

3. Warranty. Provide materials with a manufacturer's warranty, transferable to the MDOT, that the supplied materials are free from all defects in materials and workmanship. Furnish the warranty and other applicable documents from the manufacturer, and a copy of the invoice showing the date of shipment, to the Engineer prior to acceptance.

c. Construction. Complete this work in accordance with sections 819 and 820 of the Standard Specifications for Construction, as shown on the plans and as directed by the Engineer.

d. Measurement and Payment. The completed work, as described, will be measured and paid for at the contract unit price using the following pay item:

Pay Item	**Pay Unit**
Cabinet, NEMA Type	Each

Cabinet, NEMA Type includes:

1 Installing the traffic signal cabinet, and accessories required to provide the traffic signal control operation as shown on the plans and in accordance with the *MMUTCD* and this special provision.

2. Furnishing and delivering the cabinet to the maintaining agency for cabinet setup.

3. Transporting the cabinet from the maintaining agency to the job site for installation.

The Engineer may process a partial payment for units delivered to MDOT signals shop or other approved location after initial inspection and acceptance and after the Contractor provides either a paid invoice/proof of payment or a receipt for delivery. If payment is based on the delivery invoice, the Contractor must provide a copy of the paid invoice/proof of payment to the supplier within 10 calendar days of the prime Contractor receiving payment for the materials. Partial payments for delivered materials/units meeting all project specifications will be limited to the smaller of the actual invoice amount or 96 percent of the contract bid amount. Final payment will be processed after final acceptance of the individual traffic signal installation.