FLORIDA

DEPARTMENT

OF

TRANSPORTATION

Minimum Specifications
for
Traffic Control Signals and Devices

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STATE TRAFFIC ENGINEERING AND OPERATIONS OFFICE
TRAFFIC ENGINEERING RESEARCH LABORATORY
TALLAHASSEE, FLORIDA

http://www.dot.state.fl.us/trafficoperations

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PREFACE

PURPOSE:

The purpose of the ***Minimum Specifications for Traffic Control Signals and Devices (MSTCSD)*** document is to define the Florida Department of Transportation (FDOT) "Minimum Specifications" for use in the evaluation and certification of all traffic control signals and devices introduced into the State of Florida.

This document contains MATERIAL specifications. Installation specifications for the equipment in this document are contained in the FDOT's ***Standard Specifications for Road and Bridge Construction***; however, some installation requirements may also be contained herein.

Pursuant to Florida Statute 316.0745 all official traffic control signals or official traffic control devices purchased and installed in the state by any public body or official shall conform with the manual and specifications published by the Department of Transportation. The statute also states that it shall be unlawful for any public body or official to purchase, or for anyone to sell, any traffic control signal or device unless it conforms with the manual and specifications published by the Department of Transportation and is certified to be of such conformance prior to sale.

Traffic control signals and devices are defined as any signal or device, manually, electrically or mechanically operated, by which traffic is alternately directed to stop and permitted to proceed or controlled in any manner. Traffic control signals and devices regulate, warn, or guide traffic on, over or adjacent to a street, highway, pedestrian facility, or bikeway by authority of a public agency having jurisdiction. Traffic control signals and devices include, but are not limited to, controller assemblies (controller cabinets and their contents); signal heads including their hanging or mounting devices; vehicle detection systems (loops, sealant, amplifier, lead-in wire, or cable); pedestrian detection systems (push button, push button housing, lead-in wires, and signal); Motorist Information Systems (dynamic message signs, highway advisory radios, etc.), Video Equipment (CCTV cameras, etc.), Network Devices (field Ethernet switches, encoder, decoders, device servers, etc.), Vehicle Detection Systems, and other equipment used within a traffic control system.

This document is referenced in the FDOT's current ***Standard Specifications for Road and Bridge Construction*** and contains the MINIMUM technical criteria used in the certification and approval of traffic control signals and devices.

These specifications must be met to obtain certification or approval of a traffic control signal or device. The signal or device must be approved before it can be sold or installed in the state of Florida.

These specifications are compiled and published by the State Traffic Engineering and Operations Office in Tallahassee, Florida, and are issued in accordance with the provisions of Florida Statute Chapter 316.0745.

These specifications update and replace the following preceding FDOT specifications and all addendums associated with them:

1) *Minimum Specifications for Traffic Control Signal Devices,* July 2000.
2) *Minimum Specifications for Traffic Control Signal Devices*, December 1999.
3) *Minimum Specifications for Traffic Control Signals and Devices*, February 1994.
4) *Interim Specifications for 170 Traffic Controller Assemblies*, Revision 1.1, February 1994.
5) *Evaluation Criteria for Traffic Control Devices* May 1991.
6) *Supplemental Specifications to the 1986 Standard Specifications for Road and Bridge Construction*.

AUTHORITY:

Florida Statute Chapter 316.0745, State Uniform Traffic Control;

DEFINITIONS AND TERMS

Wherever the following terms or abbreviations are used, the meaning shall be interpreted as follows:

A	Ampere
AC	Alternating Current
AC+	120 Volts AC, 60 hertz ungrounded power source
AC-	120 Volts AC, 60 hertz grounded return to the power source
ACIA	Asynchronous Communications Interface Adapter Device
APL	Approved Product List
ASCII	American Standard Code for Information Interchange
Assembly	A complete unit that was manufactured by fitting together parts and/or modules
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
CFR	Code of Federal Regulations
Channel	An information path from a discrete input to a discrete output
CMOS	Complementary Metal Oxide Semiconductor
Component	Any electrical or electronic device
Controller Unit	That portion of the controller assembly devoted to the operational control of the logic decisions programmed into the assembly
CPU	Central Processing Unit
CV	Conflict Voltage
DC	Direct Current
DPDT	Double Pole, Double Throw
DTOE	District Traffic Operations Engineer
EEPROM	Electrically Erasable, Programmable, Read Only Memory
EIA	Electronic Industries Association
EMI	Electro-Magnetic Interference
EPROM	Erasable Programmable Read-Only Memory
Equal	Connectors: comply with physical dimensions, contact material, plating and method of connection. Devices: comply to function, pin out, electrical and operating parameter requirements, access times and interface parameters of the specified device
FHWA	Federal Highway Administration
Hz	Hertz
IC	Integrated Circuit
IEEE	Institute of Electrical and Electronics Engineers IMSA International Municipal Signal Association
ISO	International Standards Organization

ITE	Institute of Transportation Engineers
LED	Light Emitting Diode
LOGIC	Negative Logic Convention (Ground True) State
m	Milli
MIL	Military Specifications
MODEM	Modulation/Demodulation Unit
Module	A functional unit that plugs into an assembly
MOS	Metal-Oxide Semiconductor
Motherboard	A printed circuit connector interface board with no active or passive components
MOV	Metal Oxide Varistor
N	Newton: SI unit of force
n	nano
NA	Presently Not Assigned. Cannot be used by the contractor for other purposes
N.C.	Normally closed contact
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
N.O.	Normally open contact
NPS	Nominal Pipe Size
NPT	National Pipe Thread
NRTL	Nationally Recognized Testing Laboratory
PCB	Printed Circuit Board
PDA	Power Distribution Assembly
PROM	Programmable Read Only Memory
psi	Pounds per Square Inch
REA	Rural Electrification Association
RF	Radio Frequency
RMS	Root-Mean-Square
ROM	Read Only Memory Device
s	second
SW	Switch
TB	Terminal Block
u	Micro
UL	Underwriter's Laboratory
VAC	Voltage Alternating Current
VDC	Voltage Direct Current
Vendor	A manufacturer, firm, partnership, corporation or combination thereof, who represent a product for approval consideration.
VMA	Valid Memory Address

WDT	Watch Dog Timer

SECTION A601
TRAFFIC CONTROL SIGNAL AND DEVICE EVALUATION AND CERTIFICATION/APPROVAL

A601-1 Description

This section provides general information and requirements for the evaluation and certification/approval of official traffic control signals, official traffic control devices, and related ancillary or system equipment (hereafter referred to as Traffic Control Signals and Devices) submitted for listing on the FDOT Approved Product List (APL).

A601-2 Minimum Specifications Requirement

All traffic control signals and devices sold within the state of Florida shall conform to the requirements of these specifications, the ***Minimum Specifications for Traffic Control Signals and Devices (MSTCSD).*** In addition, all traffic control signals and devices must comply with the latest edition of the Federal Highway Administration's (FHWA) ***Manual on Uniform Traffic Control Devices (MUTCD),*** the ***FDOT Standard Specifications for Road and Bridge Construction,*** and the ***FDOT Design Standards,*** where applicable. Exceptions to these specifications may be granted by the FDOT in order to evaluate or allow new technology in accordance with Florida Statute 316.0745. Failure of the manufacturer to comply with these specifications during initial product submittal or after product approval will result in denial of approved status or removal of the device from the APL, respectively.

The certification and approval process for traffic control signals and devices is described in the ***FDOT Traffic Engineering Manual, Section 7.1***.

A601-3 Independent Testing Laboratory and Test Reporting Requirements

When an Independent Testing Laboratory report is required as part of an evaluation, the following requirements apply:

1) The laboratory and its personnel shall not in any way be associated with the manufacturer or any parent or subsidiary of same.
2) The laboratory report shall be neatly organized in a binder that includes tab-separated sections and contain a CD or other storage device for storing the electronic form of the report.
3) The laboratory report shall contain the following at a minimum:
    a) The test procedure and date of testing.
    b) A description of the test equipment used including last calibrated date, calibration due date, calibration range and a current certificate of calibration.
    c) The test conditions.
    d) The product specifications.

e) The test results including measurement of uncertainty for each test and a pass/fail status relative to each product specification.
f) Product part number and date of manufacture of product being tested.
g) Before and after-test photographs of the product being tested
h) Photographs of the test set-up and location of gauges (if used)
i) Name and title of person performing test
j) Description of the location and type of failure and photographs of each failure

A601-4 Certified/Approved Product Engineering Change Notifications

The Traffic Engineering Research Lab must be notified of any modification or alteration of a certified/approved device including design, materials, or operational improvements for review and, if needed, re-evaluation or removal of the device from the APL may occur. Inspection and testing may be conducted to assure continued compliance.

A601-5 Traffic Control Signal and Device Identification

All devices submitted for listing on the APL shall include, as a minimum, the following identification and shall be accomplished by permanently affixing an indelible label, identification plate, dot peen type stamp, or other approved method:

1) Name and/or trademark of the manufacturer
2) Part number
3) Date the product was manufactured
4) FDOT approval number (sample method of marking must be provided during the approval process.)

Affix the FDOT approval number as follows:

1) On the top front center of controllers, vehicle detectors, etc.;
2) Inside the housing near the terminal block of vehicular and pedestrian traffic signals, electromechanical/electronic signs, and pedestrian detectors;
3) Inside the main cabinet door of all cabinets such as controller and dynamic message sign cabinets.
4) Inside the housing on electronic display signs and internally illuminated signs.

Signal hardware shall be marked as follows: All required identification shall be cast or metal-marked into the product. Each product with an APL approval number shall be marked as noted in 1 through 4 above. Each subcomponent of an assembly shall be marked as noted in items 1 through 4 above.

SECTION A602
MANUFACTURING PROCESS QUALITY ASSURANCE REQUIREMENTS

A602-1 Description

Manufacturing facilities and vendors of all products listed on the FDOT's APL shall be qualified as meeting the FDOT minimum quality assurance (QA) standards before the product(s) can be submitted for evaluation and must maintain their qualification status in order for the product(s) to remain on the APL.

Quality is defined as "Conformance to valid customer requirements including laws, rules, procedures, policies and standards."

Quality assurance is defined as, "The activity of providing fact-based evidence that verifies quality products, services, and information are being delivered."

Quality control is defined as, "The activity of implementing, monitoring and continuously improving processes to ensure delivery of quality products, services, and information."

A602-2 Qualification Requirements

To obtain qualification, manufacturers and vendors must successfully pass the FDOT Quality Assurance Evaluation by satisfactorily demonstrating that the quality management system (QMS) meets the FDOT's minimum requirements as listed in these specifications. To begin the qualification process, a completed FDOT Quality Assurance Evaluation Survey must be submitted and will be evaluated to determine the company's QA system compliance with minimum specification A602. The QA Survey shall be filled out in English and all supporting documentation shall be translated into English if the originals are in a language other than English. The survey can be accessed at http://www.dot.state.fl.us/TrafficOperations. Manufacturers and vendors must allow on-site audits of their facilities and present information regarding their quality system at the FDOT's facility, if requested. At a minimum, a manufacturing process video must be supplied (specific video requirements are detailed in the Survey). Personnel with a background in quality assurance or a third party quality consultant must be assigned to prepare the qualification submittal package and be allowed to work with FDOT staff during the evaluation of their quality system.

The following requirements apply:

A602-2.1 Single Manufacturing Facility

Companies seeking initial qualification for a single manufacturing facility shall submit a completed QA Evaluation Survey for the manufacturing facility.

A602-2.2 Multiple Manufacturing Facilities

Companies seeking initial qualifications for multiple manufacturing facilities shall submit a completed QA Evaluation Survey for each manufacturing facility as part of a single submittal.

A602-2.3 Use of OEMs or Subcontractors

Companies selling products from original equipment manufacturers (OEMs) under their own brand name or hiring subcontractors for product design/manufacturing/testing and seeking initial qualification shall submit a completed QA Evaluation Survey. Such companies shall notify the FDOT in writing of the arrangement with the OEMs/subcontractors at the time of submittal and clearly delineate the scope of activities between themselves and the OEMs/subcontractors. In addition, the FDOT may require each OEM/subcontractor to concurrently submit a completed Survey depending on the extent of the subcontracted activities.

A602-2.4 Changes in OEMs or Subcontractors

This section applies to companies using OEMs or subcontractors as determined by the FDOT (refer to A602-2.3). Qualified or requalified companies described in A602-2.3 changing OEMs/subcontractors before the end of the qualification period shall notify the FDOT in writing of the change in OEM/subcontractor at the time of change. Separate completed QA Evaluation Surveys shall be concurrently submitted six months following the change of OEM/subcontractor by both the company and each OEM/subcontractor. This time frame is expected to be sufficient to allow both company and OEM/subcontractor to accumulate quality records in order to provide documentation supporting evidence of implementation of the QMS.

A602-2.5 Relocating of Manufacturing Facility

Qualified or requalified companies relocating their manufacturing facility before the end of the qualification period shall notify the FDOT in writing of the plant relocation at the time of the relocation. A completed QA Evaluation Survey shall be submitted six months following plant relocation. This time frame is expected to be sufficient to allow the company to accumulate quality records in order to provide documentation supporting evidence of implementation of the QMS.

A602-2.6 Changes in Company Ownership

Qualified or requalified companies merging with other companies before the end of the qualification period shall notify the FDOT in writing of the merger at the time of the merger. If the already approved QA documentation is affected by the merger, the company shall submit a list of updates to the FDOT at the time of notification. Depending on the extent of the updates, the FDOT may require a completed QA Evaluation Survey be submitted six months following the companies' merger. This time frame is expected to be sufficient to allow the company to accumulate quality records in order to provide documentation supporting evidence of implementation of the QMS.

A602-3 Quality Assurance Manual

A QA manual must be established and maintained; all issued copies must be controlled. The QA manual shall contain all policies associated with the manufacturing facilities operation. These policies shall be actionable, adequately rendered and distributed throughout the organization in order to establish QA consistency.

The QA manual shall maintain a standard format including but not limited to:

1) Cover Page - Contains document name, owner's name, address, revision, identification and date.
2) Revision page – Keeps track of all revisions and is duly signed by authorized personnel.
3) Table of contents.
4) Content – Subjects / sections shall be sequentially indexed. Each section shall contain, but not be limited to, the following sub-sections:
    a) Policy.
    b) Purpose.
    c) Definitions and responsibility.
    d) Requirements.
    e) Citations of or references to other applicable documents for details and specific instructions (i.e., procedures, work instructions, diagrams, flow charts, specifications, etc.).
    f) Appendix.
    g) Reference.

At a minimum, the QA manual shall contain the following:

1) Quality policy.
2) Quality objectives.
3) Scope of the quality management system.
4) Organization chart showing functional responsibilities of all key personnel (including QA personnel).
5) Policy for document control.
6) Policy for management responsibility (including management review).
7) Policy for resource management (including training).

8) Policy for design and development (including control of design and development changes).
9) Policy for purchasing (including evaluation/selection of suppliers and subcontractors and inspection/testing of incoming material).
10) Policy for inspection and testing (in-process and finished goods).
11) Policy for production and service provision (including product identification / traceability, production control, handling/packaging of product).
12) Policy for control of measuring and monitoring devices (test equipment).
13) Policy for monitoring customer satisfaction.
14) Policy for quality audits.
15) Policy for control of non-conforming material.
16) Policy for continuous improvement (including analysis of data to improve customer satisfaction, process performance and product quality).
17) Policy for corrective and preventive actions.

A602-4 Work Procedures Manual

Procedures shall be included in the QA manual or be part of another separate procedures manual. In the latter case, procedures shall be referenced within the QA manual. Such procedures shall support policies defined in the QA manual. Procedures shall define and control the work that should be done, and explain how it should be done, who should do it, and under what circumstances. In addition, they shall explain what authority and what responsibility has been allocated, which inputs should be used, and what outputs should be generated. Each procedure shall maintain a standard format including, but not limited to:

1) Cover section – Contains document name, owner's name, address, revision identification and date.
2) Revision section – Keeps track of all revisions and is duly signed by authorized personnel.
3) Content – Each procedure shall contain, but not be limited to the following sub-sections:
   a) Purpose.
   b) Scope.
   c) Definitions.
   d) Requirements.
   e) Inputs and outputs.
   f) Citations of or references to other applicable documents, typically other procedures, work instructions, data forms etc.

At a minimum, the following procedures shall be provided:

1) Document control.
2) Management responsibility (including management review).
3) Training.
4) Design and development (including control of design and development changes).
5) Purchasing (including evaluation/selection of suppliers and subcontractors and inspection/testing of incoming material)
6) Production control.
7) Handling, packaging and preservation of product.
8) Inspection and testing of in-process and finished goods.
9) Product identification and traceability.
10) Control of inspection, measuring and test equipment.
11) Analysis of data to improve customer satisfaction, process performance and product quality.
12) Customer satisfaction.
13) Quality audits.
14) Control of non-conforming material.
15) Corrective and preventive actions

A602-5 Document Control

A document control system shall be established that will capture, store and sustain information and data in a timely and sequential manner. The document control system should be able to keep track of all internal and external documentation. Documentation traceability shall be governed by document name and identification index and date. This system shall facilitate and enhance information review and investigation which can be used for research and improvement. It shall also ensure that the current revision documents are available at the point of use.

A602-6 Management Responsibility

The top management shall provide evidence of its commitment to the development and maintenance of the QMS including, but not limited to:

1) Communicating of the importance of meeting the customer regulatory and legal requirements.
2) Maintaining and communicating the quality policy.
3) Ensuring that quality objectives are established and routinely evaluated.
4) Routinely conducting management reviews of the QMS.
5) Ensuring the QMS is given adequate resources.
6) Ensuring that the responsibilities and authority are defined and communicated within the organization. This also implies assigning members of management for these tasks.

A602-7 Resource Management

A documented system shall be in place to ensure that all employees who affect the quality of products or services are qualified or trained to ensure consistent output. Quality records shall be in place to show training requirements and completeness of training.

A602-8 Design and Development

New design or design improvement/change activities shall be documented, thoroughly reviewed, tested and approved by authorized personnel prior to implementation. Design and development inputs/outputs shall be clearly recorded and reviewed to ensure outputs meet and/or exceed inputs. In particular, outputs shall include complete documentation for manufacturing new and/or modified existing products. There shall be a process that allows design changes that effect the product currently being used in the field (i.e., firmware/software updates, obsolete components due to new changes, etc.) to be duly documented and communicated with the end user in writing.

A602-9 Production Control

Clearly outlined procedures, instructions, flow charts and other related documents and practices shall be established in order to standardize processes for the following activities:

1) Raw material receiving and inspection.
2) Product identification and traceability
3) Control of non-conforming materials and products
4) Production setup.
5) Manufacturing and/or assembly activity control.
6) Inspection, testing and sampling.
7) Non-conformance, corrective and preventive actions.
8) Packaging, inventory and shipping.
9) Equipment calibration control.

A602-10 Inspection and Testing

Inspection and testing criteria shall be established, documented and periodically reviewed for continuous improvement. Findings of all inspections and testing shall be documented for audits, review and continuous improvement. The following activities shall require documented inspection and testing:

1) Raw material / component receiving and inventory.
   a) All raw material and components upon receipt shall be coded for identification purposes. The code shall include supplier identification, batch identification, date material was ordered and received, and production purpose.

b) Incoming materials shall be inspected and/or tested against specifications and/or requirements. Defective items shall be tagged, segregated and placed in a designated area.

2) Production setup shall be performed with utilization of a check list. Setup activity shall cover, but not be limited to, the following systems:
   a) Machinery and equipment.
   b) Measurement tools calibration verification.
   c) Raw material/component type and quantity/measurement verification
3) Manufacturing and/or assembly activities
   a) Production line:
      i) Inspection and testing for in-process and completed items shall be established at appropriate intervals along manufacturing lines and against specifications and/or requirements.
      ii) Non-conforming items shall be tagged and segregated for scrapping or re-work.
   b) Traceability
      i) Finished product shall be adequately marked with weather resistant permanent labels.
      ii) Permanent marking shall at least include date of manufacture, vendor identification and product identification (part number, batch/lot/serial number etc.).
      iii) This information shall allow a product to be traced to documents that would show all manufacturing activities related to the product, such as raw material information, personnel involved in the manufacture of the product, and test and inspection data, etc.
4) Packaging, inventory and shipping shall include, but not be limited to, meeting the following criteria:
   a) Pre-packaging inspection:
      i) Verify that all inspection and testing documents are signed and approved.
      ii) Verify that all products are marked and labeled in accordance with section A601.
   b) During packaging:
      i) All products shall be packaged to withstand extreme shipping conditions, including but not limited to, impacts, vibration, and excessive heat.
      ii) Handling instructions must be clearly printed on the packaging to indicate equipment upright position and recommended method of handling.
   c) Post-packaging inspection / inventory:
      i) Packages shall be inspected for damages and approved prior to shipping.
      ii) Packages awaiting shipping shall be placed in a designated area and handled in accordance to specification (i.e., stacking allowed or not).

5) Calibration activity shall be performed for instruments/equipment used for measuring and testing when required by the equipment manufacturer. All information pertaining to calibration activities shall be documented and periodically reviewed.
   a) Decision for calibrating an instrument shall be made under the following circumstances:
      i) Calibration due – triggered by calibration expiry date printed on the tag which is placed onto the instrument.
      ii) Equipment experienced malfunctions or damage – triggered by an accident report, a corrective action report, etc.
      iii) Production batch fails to meet specification – triggered by inspection and testing non-conformance, rejected delivery, customer complaint, etc.
   b) All equipment that requires outside calibration shall be performed by a certified agency, documented by calibration certificates issued by the agency.
   c) Equipment that allows in-house calibration shall be controlled by documented calibration procedures. Performance of in-house calibration shall be reviewed and approved by the engineering manager and followed by test runs. Test run data shall be documented accordingly and approved by the engineering manager.

A602-11 Purchasing

A supplier selection system shall be established and maintained. The selection system, at a minimum, shall include a survey that will scrutinize the suppliers in the following areas:

1) Financial stability.
2) Manufacturing capabilities.
3) Quality requirements (including but not limited to supplier audits).

All information pertaining to a specific supplier shall be documented (i.e., number of rejections of raw materials, delivery tardiness, audits etc.) for periodic review and supplier reevaluation purposes. An up-to-date and approved supplier list (or excerpts from) shall be submitted at the time of application.

A602-12 Monitoring and Measurement

A602-12.1 Internal Audits

Internal audits shall be performed at least once a year to determine if the quality system is effectively implemented and maintained. The audits shall cover, but not be limited to, the following aspects:

1) Management.
   a) Organization updates.
   b) New policies and updates.

   - c) Goals review and new goals setting.
   - d) Asset and inventory review.
   - e) Production review.
   - f) Customer service review.
- 2) QA systems.
   - a) Review of document control and updates.
- 3) Production.
   - a) Production document control review.
   - b) Internal nonconformance notifications review.
   - c) Corrective and preventive actions reports review.
   - d) Equipment maintenance and calibration review.
- 4) Customer service.
   - a) Customer complaints.
   - b) Corrective and preventive actions reports.
- 5) Personnel development.
   - a) Training.
- 6) Safety.
   - a) Work environment safety review.

Audit findings and suggested corrective actions shall be documented and pursued until all issues are resolved.

A602-12.2 Customer Satisfaction.

Information about customer perception and the ability of the company to meet the customer requirements shall be monitored by the organization. Systems shall be in place for obtaining and using information related to customer satisfaction.

A602-13 Continuous Improvement

A system shall be in place for continually improving the effectiveness of the quality management system. Results of audits, management reviews, corrective and preventive actions, and analysis of data shall be used for continuous improvement of the quality management system, processes and products.

Corrective and preventive actions shall be taken and documented to eliminate the cause of nonconformities and to prevent further non-conformities. When deemed applicable, a root-cause analysis shall be performed as part of the corrective/preventive action process. The effectiveness of these actions shall be reviewed to confirm the actions were successful.

A602-14 ISO Registration

Companies whose QMS is registered through the International Organization for Standardization (ISO) shall furnish a current certificate of registration along with the most recent registrar's audit report. Companies manufacturing permanent mount dynamic message signs (DMSs) and seeking FDOT certification of such product(s) must submit a current certificate of ISO 9001 registration and the most recent registrar's audit report.

A602-15 Requalification

Requalification is performed every four years from the date a company was qualified or requalified. Earlier requalification may be required depending on product or company related issues (for example: product quality, safety, customer service). The results of the requalification are dependent upon the company's response to the submittal requirements (listed below) and Florida end user comments.

Upon reaching the requalification date, the company shall submit a completed QA Requalification Survey to the FDOT. The survey can be accessed at http://www.dot.state.fl.us/TrafficOperations. The Survey shall be filled out in English and all supporting documentation shall be translated into English if the originals are in a language other than English.

A602-15.1 Timing of Submittals

Timing requirements and associated consequences are as follows:

1) Requalification Due Date. A completed QA Requalification Survey must be received no later than the "Requalification Due" date posted for the company and listed on the FDOT's "Vendor Manufacturing Process Qualification List" located at http://www.dot.state.fl.us/TrafficOperations.
2) Notice of Requalification Due. In the event that the requalification submittal is not received by the "Requalification Due" date, the company will be given a requalification submittal notice by the FDOT.

   The company shall have 30 calendar days from the date of the notice to respond and deliver the requalification submittal to the FDOT.

3) Notice of Corrective Action (NOCA). A NOCA will be issued by the FDOT when the company fails to meet the first 30-day deadline.

   The company shall have another 30 days to respond to the NOCA.

4) Notice of Suspension (NOS). Failing to meet the second 30-day deadline will result in suspension of the company's "qualified" status. This information will be communicated to the company by the FDOT via a NOS. Under suspension, all products manufactured by the company and listed on the APL will be masked from public view making them ineligible for sale within the state of Florida.

   The company shall have another 30 days to respond to the NOS.

5) Notice of Revocation (NOR). Failure to meet the third and final 30-day deadline will result in the company's "qualified" status being revoked. This information will be communicated to the company by the FDOT via a NOR. Under revocation, company qualification is rescinded and all products manufactured by the company and listed on the APL are removed from the APL. The company may be required to wait up to one year before resubmitting for qualification and a new completed QA Evaluation Survey must be submitted**.**

In all cases, requalification must be achieved within six months following the "Requalification Due" date. Failure to requalify within this time frame will lead to a NOS sent to the company by the FDOT.

A602-15.2 Submittal Requirements

During requalification, the company must demonstrate that the quality system standards met during the previous qualification have been maintained by providing the following information. This information must be reflective of the last two years unless otherwise indicated.

1) A current certificate of ISO registration for companies that are ISO registered and the latest ISO registrar's audit report.
2) A current certificate of ISO 9001 registration for companies with FDOT approved permanent mount DMSs and the latest ISO registrar's audit report.
3) Changes to company ownership, management, quality system, OEMs/subcontractors, manufacturing facility location, number of manufacturing facilities and products listed on the APL.
4) List of updates to the QA and Work Procedures Manuals.
5) For products listed on the APL, evidence of sales in the state of Florida during the previous four years. Any device not sold in the state of Florida within the previous four years may be removed from the APL.
6) Responses to comments noted in the last FDOT (re)qualification letter.
7) Responses to findings during plant audits by FDOT staff (if applicable).
8) Manufacturing facility quality audit reports (internal).

9) Manufacturing facility quality audit reports (by a third party).
10) Management review meeting reports.
11) OEM/subcontractor manufacturing facility quality audit reports (if manufacturing activities are subcontracted).
12) Corrective and preventive action reports pertaining to:
    a) Quality system.
    b) Manufacturing process.
    c) Products on the APL (resulting from customer complaints and/or internally triggered). All corrective/preventive action reports created during the previous (re) qualification period must be provided for this item.
    d) Customer service concerning APL products. All corrective/preventive action reports created during the previous (re) qualification period must be provided for this item.

A602-15.3 Florida End User Review

Concurrent with the requalification, a survey of the company's products sold in Florida may be performed by the FDOT to determine the level of customer satisfaction and product performance. If there have been any disputes, complaints or nonconformities with products or services, the company will be required to provide a root-cause-analysis and corrective action report showing how the issues were resolved, and any documentation that was generated as a result of the corrective action activity.

SECTION A610
TRUCK MOUNTED INCIDENT MANAGEMENT
DYNAMIC MESSAGE SIGN

A610-1 Description

This section specifies the minimum requirements for the certification of truck mounted incident management dynamic message signs. This equipment is for “first response” vehicles (trucks) responding to an incident. No trailer mounted signs will be accepted. **This equipment is not to be used for planned events.** All traffic control devices of this type must also meet the physical display and operational requirements as described in the Federal Highway Administration’s ***Manual on Uniform Traffic Control Devices (MUTCD)***. The message display shall utilize light emitting diodes (LED). Alternate illumination technology may be submitted for approval as long as the functional requirements of this specification are met.

A610-2 Display Panel and Housing

1) The housing maximum size shall not exceed the following: width = 72 inches (6 feet); height = 48 inches (4 feet); thickness = 12 inches (1 foot).
2) The housing shall be designed to withstand exposure to the elements and offer some degree of protection against vandalism.
3) All nuts, bolts, washers and other fasteners (less than 5/8") shall be stainless steel type 304 or 316.
4) Provisions (by convection or fan) shall be made for heat dissipation within the unit.
5) The message matrix panel background and frame for the changeable message assembly shall be painted flat black, federal specification TT-E-489.
6) The face of the display shall be easily opened from the front, and locked to stay open far enough to allow for servicing of all message panel components.
7) All message panels shall aid against sun glare. The face of the sign shall be covered by an impact resistant polycarbonate non-glare face with an ultraviolet inhibitor to protect from fading and/or yellowing.
8) The display panel support structure, when raised in the upright position, shall be designed to allow for a minimum height of seven feet from the bottom of the panel to the ground and shall be a minimum of one inch above the height of any light bar mounted on the cab of a truck. The highest part of the unit, when in the travel or rest position, shall be no greater than 7.5 feet above the ground. The unit shall have a manual and automatic control mechanism to raise and lower the display assembly. A locking device shall also be provided to ensure the display panel will remain in the raised or lowered position.

A610-3 Message Matrix

1) The message display area shall be a minimum of 36 inches (three feet) high by 60 inches (five feet) wide.
2) The display shall provide variable letter, graphic and symbol sizes from 9 to 36 inches.
3) LEDs used shall be amber (590 nm dominate wavelength) and shall meet the visibility requirements of this specification. LEDs shall have a viewing angle no less than 30 degrees. LED intensity shall not fall below 80 percent within three years.
4) All display modules shall be identical and interchangeable.

A610-4 Electrical System

1) The power supply shall be a 12 VDC system designed to operate the sign with a dedicated battery or batteries that are charged by the vehicle electrical system, but isolated so it does not drain the vehicle battery.
2) All internal sign components shall be treated with a protective, weather-resistant polyurethane conformal coating to protect against the adverse effects of humidity and moisture.

A610-5 Controller

1) The controller shall be housed inside the sign and shall be equipped with a security lockout feature to prevent unauthorized use.
2) An external weather-resistant, hand-held control keypad shall be used to display the message on the sign.
3) The sign shall not be affected by radio transmissions.
4) The controller shall have the capability to provide a stipulated default message upon loss of controller function. A blank message is acceptable.

A610-6 Operation and Performance

1) The message shall be displayed in upper case.
2) The message matrix panel shall be visible from one-half mile. With a 9-inch character displayed, the sign shall be legible from a distance of 400 feet in both day and night conditions. Under variable light level conditions, the sign shall automatically adjust its light source to meet the 400-foot visibility requirement.
3) The sign shall have the capability to store a minimum of 40 common messages / graphics of which a minimum of 30 shall be user-programmable messages.
4) All messages shall be capable of being flashed or sequenced. In the sequence mode, the controller shall have the capability to sequence three complete messages during one cycle. A displayed message shall not exceed three lines. Both message dwell time and message flash rate shall be individually programmable.
5) The sign assembly shall be designed for operation in ambient temperature ranges from -30 to +165 degree Fahrenheit at 5 percent to 95 percent relative humidity, non-condensing. Other

environmental requirements shall be followed as specified in Section A615 of the FDOT's ***Minimum Specifications for Traffic Control Signals and Devices***.

A610-7 Other Requirements

1) The sign shall be secured on the vehicle for normal operation.
2) The sign's total weight (including all mounting brackets) shall not require a forklift to lift onto a truck (i.e., must be able to be loaded be hand using only 2-3 people).
3) A fault light, visible to the driver, shall be located on the sign to indicate if it is not operating properly.
4) An operator's manual shall be furnished with each sign.
5) The following shall be painted or affixed with a permanent tamper-proof, water-resistant label located on the driver's side of the housing:
   a) Manufacturer name
   b) FDOT Certification Number
   c) Message stating: **"Certification of this device by the Florida Department of Transportation allows for its use for Incident Management only."**

SECTION A615
ENVIRONMENTAL REQUIREMENTS

A615-1 Description

This section provides minimum environmental requirements for the certification of the following types of equipment: traffic signal controllers, signals, vehicle detectors and their detection devices, load switches, flashers, conflict monitors, external logic units, preemption units and their detection devices, communication units, any equipment which has a logic, timing, or communication function, roadside electronics, or any other device deemed necessary by the FDOT. An independent lab test report shall be provided stating that the device meets the following requirements.

All equipment intended for installation outdoors or within a roadside cabinet shall operate as specified during and after being subjected to the transients, temperature, voltage, humidity, vibration, and shock tests described in National Electrical Manufacturers Association (NEMA) TS2, 2.2.7, 2.2.8, and 2.2.9. Traffic signal controller assemblies including Controller Unit (CU), Malfunction Management Unit (MMU), Bus Interface Units (BIUs), Cabinet Power Supply, Load Switches, Flasher(s), and Detector(s) must meet or exceed all requirements specified in NEMA TS2.

A615-2 Operating Voltage and Frequency

A615-2.1 General

All equipment shall perform as specified when the voltage and frequency from the local service transformer are within the following specified limits.

A615-2.2 Voltage

The voltage range shall be from 89 to 135 V_{RMS} alternating current. The nominal voltage shall be 120 V_{RMS} alternating current.

A615-2.3 Frequency

The operating frequency range shall be 60 ± 3 Hz.

A615-3 Power Interruption

Power interruption requirements are only applicable to traffic signal controllers. The power interruption shall define the controller mode of operation upon restoration of power relative to the length of time the power has been interrupted. Two or more power interruptions separated by power restoration of 1500 ms or greater shall be considered as separate interruptions, and the controller shall react to the power interruptions as follows:

1) Interruption of 500 ms or less – Upon restoring power, the controller shall continue to operate as though the power interruption had not occurred.
2) Interruption of more than 600 ms and less than 1000 ms – Upon restoring power, the controller shall either continue to operate as specified above or shall revert to its start-up sequence.
3) Interruption of 1000 ms or more – Upon restoring power, the controller shall revert to its start-up sequence. Three interruptions of 300 ms or less which are separated by power restorations of 300 ms or more shall not cause the controller to revert to its start-up sequence.

A615-4 Temperature and Humidity

A615-4.1 General

Equipment shall operate as specified when the ambient temperature and humidity are within the following specified limits:

A615-4.2 Ambient Temperature

1) The operating ambient temperature range shall be from - 30° to 165°F (-34.4° to 73.8°C).
2) The storage temperature range shall be from -50° to 185°F (-45.5° to 85°C).
3) The rate of change in ambient temperature shall not exceed 17°C per hour, during which the relative humidity shall not exceed 95 percent.

A615-4.3 Humidity

The relative humidity shall not exceed 95 percent over the temperature range of 40°F to 110°F (4.4° to 43.3°C). Above 110°F (43°C), constant absolute humidity shall be maintained, which results in the relative humidity shown in the table below. The relative humidity shown in this table is for dynamic testing:

At 101 kPa Barometric Pressure		
Dry Bulb (°C)	**Relative Humidity (%)**	**Wet Bulb (°C)**
4	75	3
10	80	8
16	83	14
21	86	19
27	87	25

32	89	31
38	89	36
43	90	42
49	70	43
54	50	43
60	38	43
66	28	43
71	21	43
74	18	43

A615-5 Vibration

The equipment shall operate as specified and maintain its physical integrity when subjected to a vibration of 5 to 30 Hz up to 0.5 gravity applied in each of three mutually perpendicular planes.

A615-6 Shock

The equipment shall suffer neither permanent mechanical deformation nor any change that renders the unit inoperable when subjected to a shock of 10 gravities applied in each of three mutually perpendicular planes.

A615-7 Transients

A615-7.1 Power Service

The equipment shall operate in accordance with its specified function when the following independent test pulses occur on the alternating current power service.

1) High-Repetition Noise Transients: The test pulses shall not exceed the following conditions:
   a) Amplitude - 300 V, both positive and negative polarity.
   b) Peak Power - 2500 W.
   c) Repetition - One pulse approximately every other cycle moving uniformly over the full wave in order to sweep the complete line cycle once every three seconds.
   d) Pulse Width - 10 µs.

2) Low-Repetition High Energy Transients: The test pulses shall not exceed the following conditions:

a) Amplitude - 600 V, ±5 percent, both positive and negative polarity.
b) Energy Source - Capacitor, oil filled, 10 μF ±10 percent, internal surge impedance less than 1 S.
c) Repetition - One discharge every 10 seconds.
d) Pulse Position - Random across the complete line cycle.

A615-7.2 Input-Output Terminals

The equipment shall operate in accordance with specification requirements when the following test pulse occurs on the input-output terminals:

1) Amplitude - 300 V, both positive and negative polarity.
2) Pulse Source - 1000 S nominal impedance.
3) Repetition - One pulse per second, for a minimum of five pulses per selected terminal.
4) Pulse Rise Time - One μs.
5) Pulse Width - 10 μs.

A615-7.3 Non-Destruct Transient Immunity

The equipment shall be capable of withstanding a high-energy transient having the following characteristics repeatedly applied to the alternating current input terminals (no other power connected to terminals) without failure of the test specimen:

1) Amplitude - 1000 V, ±5 percent, both positive and negative polarity.
2) Energy Source - Capacitor, oil filled, 15 μF ±10 percent, internal surge impedance less than 1 S.
3) Repetition - Applied to the controller assembly once every two seconds for a maximum of three applications for each polarity.

After the foregoing, the equipment shall perform all of its functions upon application of nominal alternating current power.

SECTION A620
SIGNAL INSTALLATION GROUNDING

A620-1 Description

This section specifies the minimum requirements for signal installation grounding materials for traffic signal installations to provide personnel and equipment protection against faults, surge currents and lightning transients.

A620-2 Materials

Use only new materials meeting the requirements of this section. Use equipment or materials that have been tested and approved for the specific use intended by a NRTL, recognized by the Occupational Safety and Health Administration, in accordance with 29 CFR 1910.7 and that also meet the following requirements.

A620-2.1 Ground Rods

Use ground rods made of copper-clad steel with a minimum diameter of 5/8”. Ground rod sections must be a minimum of 8 feet in length and manufactured for the sole purpose of providing electrical grounding.

A620-2.2 Grounding Conductors

Use No. 6 American Wire Gauge copper insulated (green) conductor, either solid or stranded with the following exceptions: for electrical or lightning protection grounds from system ground bus or barrier plates to ground rods, and for ground rod to ground rod, use only solid copper.

A620-2.3 Exothermic Grounding Bond

Use materials from the same source, meeting the requirements of the Institute of Electrical and Electronics Engineers Standards 80 and 837.

A620-2.4 Ground Rod Coupling Devices

Coupling devices must be submitted for approval.

SECTION A630
CONDUIT

A630-1 Description

This section specifies the minimum requirements for conduit used for traffic signals and intelligent transportation systems (ITS) installations and other electrically powered or operated traffic control devices.

A630-2 Materials

Provide new conduit meeting the requirements of this section.

A630-2.1 General

Use materials that have been tested and approved for the specific use intended by a NRTL, as recognized by the Occupational Safety and Health Administration in accordance with 29 CFR 1910.7 and which also meet the following industry standards:

Schedule 40 PVC[1] ....NEMA TC-2
Schedule 80 PVC[1] ....ASTM D1785-06
Fiberglass Reinforced Epoxy[2] .... ASTM D2412-02
Intermediate Metal[3] .... ASTM A135-01, ASTM A513-06, ASTM A568 and NEC
Rigid Galvanized Metal[3] ....UL 6 and NEC
Rigid Aluminum[4] ....NEC
PVC Coated Intermediate Metal[4] ....ASTM A135-01, ASTM A513-06,
.... ASTM A568 and NEC and NEMA RN1-2005
HDPE Standard Dimension Ratio SDR 11[5] .... NEMA TC-7

A630-2.2 Conduit Applications

Use polyvinyl chloride (PVC), fiberglass or high-density polyethylene (HDPE) conduit for fiber optic cable that is exposed or placed underground along the roadway facility. Use HDPE standard dimension ratio (SDR) 11 conduit underground along limited-access facilities. Provide conduit in the size, quantity and color as shown in the plans or otherwise approved by the Engineer.

Ensure that any conduit installed above ground is designed and manufactured for use in long-term aboveground applications and is ultraviolet stabilized to prevent material deterioration.

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[1] Use conduit with solvent type slip-fit plastic couplings unless otherwise approved by the Engineer. For acceptable electrical power service conduit, meet Section 630-3 *Standard Specification for Road and Bridge Construction*.
[2] Use conduit having a minimum stiffness value of 250. Ensure that each section has a duct bell with an integral gasket on one end and a duct spigot on the other end.
[3] Use conduit that is hot-dipped galvanized, with both ends reamed and threaded.
[4] Use conduit with both ends reamed and threaded.
[5] Can be used with preassembled cable and rope-in-conduit.

Ensure that the conduit inner diameter is no less than 1¼ inches. Ensure that the conduit includes all required fittings and incidentals necessary to construct a complete installation. Ensure that the conduit system allows the fiber optic cable to maintain the minimum bend radius after installation.

A630-2.3 Locate Wire

Ensure that the locate wire is a single copper conductor with a minimum gauge of AWG #12. Furnish locate wire that is insulated using a 45-mil minimum thickness polyethylene sheath that is orange in color and marked to identify the manufacturer and the conductor size.

SECTION A632
SIGNAL AND INTERCONNECT CABLE

A632-1 Description

This section specifies the minimum requirements for cable to be used in traffic signal installations. Two specific types of cable are identified as follows:

1) Signal Cable is used to supply electrical power to vehicle and pedestrian signal heads, lane control signals, and electrically powered signs.
2) Interconnect Cable is used to transmit system information between intersections or other control points in a traffic control system.

A632-2 Materials

Use only new materials meeting the requirements of this section.

A632-2.1 Signal Cable

Use either polyethylene insulated, polyvinyl chloride jacketed signal cable conforming to the requirements of the International Municipal Signal Association, Inc. (IMSA) Specification No. 19-1 or polyethylene insulated, polyethylene jacketed signal cable conforming to the requirements of IMSA Specification No. 20-1. Use signal cable conductors of stranded copper, No. 14 AWG or larger.

A632-2.2 Interconnect Cable

Use underground interconnect cable and aerial interconnect cable, shielded, with separate support wire conforming to Rural Electrification Administration (R.E.A.) Specification P.E.-39, filled telephone cables. Use aerial interconnect cable, shielded, with integral support wire conforming to R.E.A. Specification P.E.-38, aerial telephone cables. Use only No. 22 AWG solid copper cable for a closed loop system. Use only No. 19 AWG solid copper cable for 120 VAC interconnect.

A632-2.3 Interconnect Cable Support Wire

Provide support wire, whether separate from or integral to aerial interconnect cable, having a minimum diameter of 6.35 mm and meeting the requirements in Section A634.

A632-2.4 Cable Attachment Hardware

Use attachment hardware constructed as specified in Section 603 of the SSRBC with tensile strength adequate for the application. Use stainless steel lashing wire, galvanized or stainless steel lashing rod, cable rings or self-locking cable ties of U.V. stabilized black plastic having a minimum tensile strength of 100 pounds.

SECTION A635
PULL, SPLICE AND JUNCTION BOX

A635-1 Description

This section specifies the minimum requirements for the approval of pull, splice and junction boxes listed on the Department's Approved Product List.

A635-2 Pull and Splice Box

A635-2.1 General

Box covers shall have the following identification permanently cast into their top surface.

1) The application for which it is to be used: <u>FDOT TRAFFIC SIGNAL</u> (signalized intersection applications); <u>FDOT FIBER OPTIC CABLE</u> (fiber optic cable ITS applications); <u>FDOT ELECTRICAL</u> (other electrical applications); <u>FDOT LIGHTING</u> (highway lighting applications); <u>FDOT TRAFFIC MONITORING</u> (traffic monitoring applications).
2) Manufacturer's name or logo
3) Florida DOT approval number

Date of manufacture (month/day/year) shall be permanently located on the cover.

The interior of the box shall have a permanent marking that includes the manufacturer part number, Florida DOT approval number and date of manufacture near the top of the box in a manner that is visible after installation once the cover is removed.

Pull boxes used for signalized intersection applications shall have an open-bottom design with minimum opening of 190 square inches with no one inside dimension less than 10 inches.

Pull boxes used for fiber optic cable ITS applications shall have a nominal cover dimension of 24 inches wide by 36 inches long and be at least 36 inches deep. Deviations from these minimum dimensions may be approved by the Engineer as long as the bending radius is not exceeded as required by the fiber optic cable manufacturer.

Splice boxes (vaults) shall have a nominal cover dimension of 30 inches wide by 60 inches long and be at least 48 inches deep.

A635-2.2 Material (Pull and Splice Box)

Box covers shall be constructed of concrete, polymer concrete, or cast iron. Cast iron covers shall meet American Society for Testing and Materials (ASTM) Specification A48, Class 20. All covers shall have a top surface with a minimum coefficient of friction of 0.6.

Boxes shall be constructed of concrete, polymer concrete, high density polyethylene (HDPE), or a combination of hand lay up fiberglass and polymer concrete collar. Alternate materials may be accepted if all other requirements of these specifications are met.

Box covers shall be provided with lifting slots and a flush-seating lockdown mechanism. Lockdown bolts shall be penta-head 3/8-16 UNC or ½-13 UNC (Unified National Course thread bolt). Lockdown bolts and lifting slots shall be stainless steel 304 or 316 or brass. Lockdown bolts shall be able to be removed without damaging the cover or box. The bolt and nut/threaded insert assembly shall be field replaceable.

In addition to the standard lockdown bolts, all submittals for approval shall include at least one alternative vandal-resistant option for securing the cover to the box.

A635-2.3 Testing Requirements

All Pull and Splice Boxes and materials used in the manufacturing of the boxes shall be tested in accordance with the *American National Standard ANSI/SCTE 77 2007 Specification for Underground Enclosure Integrity* with the following additional requirements.

1) Test Specimens: Specimens to be tested shall be randomly selected from normal production and shall be at least 24 hours old and shall have been maintained at a temperature of 70 to 81°F (21 to 27°C) for at least 12 hours prior to testing.
2) All gauges shall be tested and certified accurate per Section 16, 17, and 18 of AASHTO T 67 and ASTM E4.
3) Replace paragraph 7.1 of the ANSI/SCTE 77 2007 Specification with the following procedure:
   a) Perform the lateral sidewall test first.
   b) Use a 10x10 inch loading plate centered on the sidewall. Use sand or other conformable media to obtain even pressure on the load area if the sidewall has an irregular shape.
   c) Apply a load of 1,200 lbs. Wall deflection shall not exceed 0.5 inches when loaded. Deflection shall be determined as the movement of the box wall at the point of the load relative to any three of the four box wall corners. Do not test the sidewall to failure.
   d) After completing the lateral sidewall test as described above, continue product testing using paragraph 7.2 and 7.3 of the ANSI/SCTE 77 2007 Specification.

   Acceptable performance shall be according to paragraph 7.4 for Tier 15 as defined in Table 1 of the ANSI/SCTE 77 2007 specification for vertical load tests and according to paragraph c)3 above for lateral tests. The tested assembly shall not show any visual evidence of structural failure during and after the test when subjected to the following test loads:

1) Vertical Load Test on Cover: 22,500 lbs (9.07 metric tons)
2) Vertical Load Test on Box: 22,500 lbs (9.07 metric tons)
3) Lateral Load test on Box Sidewall: 1,200 lbs (544.3 kg)

A635-2.3.1 Independent Test Lab Requirements

An independent lab test report shall be provided that demonstrates compliance to these specifications. The report must be neatly organized in a binder that includes tab-separated sections and contain a CD or other storage device that includes all content in electronic format. The test lab shall be a Nationally Recognized Testing Lab and shall be accredited by a national entity in the area of the testing that is to be performed (ISO / IEC 17025 Accredited Testing Laboratory, etc.). Proof of accreditation must be submitted to and approved by the FDOT prior to testing. All testing must be performed by the approved laboratory. Testing may be performed at the manufacturer facility as long as all testing requirements stated within this specification are met.

1) Complete test results shall be provided along with a pass or fail for each requirement listed in ANSI/SCTE 77 2007 and/or required below. Test results must include the following as a minimum:
   a) Product part number, date of manufacture and date of testing
   b) Weight of product tested and ambient temperature at time of test
   c) Type of material and physical description of product tested
   d) Before and after test photographs of the product being tested
   e) Photographs of the test setup and location of gauges
   f) Test equipment used and last calibration date
   g) Name and title of person performing test
   h) Description of the location and type of failure and photographs of each failure
   i) Load verses deflection graphs for each position test
2) The test report shall also include pass or fail results for the following tests:
   a) Flexural Strength
   b) Accelerated Service
   c) Chemical Resistance
   d) Simulated Sunlight Exposure
   e) Water Absorption
   f) Flammability
   g) Cover Impact
   h) Internal Equipment Protection Test, and
   i) Coefficient of Friction Test.
3) Test results must be presented in a formal report on the test lab letterhead and be signed by a professional mechanical or structural engineer. The test lab and

professional engineer shall not in any way be associated with the box manufacturer or any parent or subsidiary of same.

4) The report must contain a summary of all results. The summary shall state whether the product passed (met the requirements of the specification) or failed each test.

A635-3 Junction Box

All boxes shall be rain-tight and free of burrs, pits, sharp corners and dents. Aerial junction boxes shall be fabricated of galvanized steel or aluminum. Aerial junction boxes mounted on support poles or structures shall have minimum inside dimensions of 8 inches wide by 8 inches long and at least 3 inches deep. Aerial junction boxes attached to cable support wire shall be the type used by the American telephone industry. Mounted junction boxes for use above ground and for mounting on poles, cabinets, bases, etc. shall be fabricated of 5052 sheet aluminum alloy with a minimum thickness of 1/8 inch. The outside surface of the cabinet shall have a smooth, uniform natural aluminum finish. All welds shall be neatly formed and free of cracks, blow holes and other irregularities. Pole and cabinet mounted junction boxes shall have minimum inside dimensions of 13 inches high by 10 inches wide and at least 3 inches deep. Base mounted junction boxes shall have minimum inside dimensions of 21 inches high, 10 inches wide and be at least 8 inches deep.

All mounted junction boxes shall be provided with a hinged door and lock as specified in Section A676. All attachment hardware shall be stainless steel type 304 or 316.

Embedded junction boxes for use in concrete substructures or superstructures shall be fabricated of galvanized steel conforming to ASTM Specification A 36. The cover of the box shall be fastened to the box with four stainless steel (type 316 or 304) screws. The embedded junction boxes shall have minimum outside dimensions of 8 inches high by 12 inches wide and at least 8 inches deep.

A635-4 Barrier Terminal Blocks

A barrier terminal block with a minimum of ten positions and rated at 600 V AC shall be mounted in all aerial and mounted junction boxes. Each terminal block position shall have two screws electrically connected by a shorting bar or other FDOT-approved method. All terminal block positions shall be numbered sequentially.

SECTION A639
ELECTRICAL POWER SERVICE ASSEMBLY

A639-1 Description

This section specifies the minimum requirements for electrical power service assemblies for either overhead service or underground service used to provide electrical power service to traffic control devices in accordance with the details shown in the ***Roadway and Traffic Design Standards***, Index No. 17736.

A639-2 Materials

Use only new materials meeting the requirements of this section.

A639-2.1 General

Use equipment or materials that have been tested and approved for the specific use intended by an Occupational Safety and Health Administration-approved NRTL in accordance with 29 CFR 1910.7 and that also meet the following requirements.

A639-2.2 Weatherhead

Use a weatherhead made of a copper-free aluminum alloy with three electrical service wire entrance holes, all meeting National Electrical Code (NEC) requirements.

A639-2.3 Conduit

Meet the requirements of Section A630. Meet the requirements of Section 562 of the SSRBC for coating all field cut and threaded galvanized pipe.

A639-2.4 Electrical Service Wire

Use No. 6 AWG stranded copper, with XHHW [cross-linked polyethylene (XLPE) high heat-resistant water-resistant] insulation, rated at 600 V in dry and wet conditions.

A639-2.5 Meter Base

Use a meter base approved by the local electric power company.

A639-2.6 Service Disconnect

A639-2.6.1 Enclosure (Cabinet)

Use an enclosure conforming to NEMA Standards for Types 3R, Type 3S or Type 4, made of galvanized steel, aluminum, stainless steel or other materials approved by the Engineer. Ensure that the enclosure has a hinged door which can be locked with a padlock. Provide padlock and two keys. Do not use external handles or switches. Ensure that the inside dimensions meet the NEC requirements. Keep the enclosure locked.

A639-2.6.2 Circuit Breaker

Use a manually resettable circuit breaker which has a current rating above the current rating of the circuit breaker to which electrical power is provided; however, do not use less than a 40A circuit breaker.

A639-2.6.3 Transient Protection Device

Use a surge lightning arrester rated for a maximum permissible line to ground voltage of 175 VAC, meeting the requirements of NEMA standards for surge arresters.

A639-2.7 Attachment Hardware

Meet the requirements of Section 603 of the SSRBC.

SECTION A650
VEHICULAR TRAFFIC SIGNAL ASSEMBLY

A650-1 Description

This Section specifies the minimum requirements for vehicular traffic signal assemblies. The FDOT requires that all new signal installations utilize vehicular traffic signal assemblies with light emitting diode (LED) red, yellow, and green signal modules (circular and arrows). Incandescent lamps are allowed only to be used as replacement parts for existing incandescent signals. All vehicular traffic signal assemblies shall also meet the requirements of the latest edition of the MUTCD and the ITE Standard for Vehicle Traffic Control Signal Heads.

The vehicular traffic signal assembly shall be provided as a complete and functioning unit, including but not limited to the following: LED signal modules, signal housings, visors, back plates, lenses, and assembly hardware. The manufacturer shall also include samples of all available lenses, reflectors, and any other accessories or components designed to be incorporated within the signal assembly. Install horizontal signal assemblies in a manner that positions the door hinges on the bottom of the signal. For vertically mounted 5-section clusters, construct the signal assembly so that door hinges are located along the outside edges of the complete signal assembly and each section opens away from the horizontally adjacent section.

A650-2 Signal Heads

A650-2.1 Assembly - 12 inch Signal Heads

The assembly shall be constructed of the materials and alloys specified in the current ITE Standards for Vehicular Traffic Control Signal Heads.

The top and bottom of each assembly shall have an opening to accommodate a TRI-STUD bracket, (*See* Section A659).

The top and bottom opening of each signal head section shall include a circular serrated connection (2-inch nominal I.D.) that provides positive positioning and alignment of the signal head sections and the complete assembly in 5 degree increments. When completely assembled and tightened in accordance with manufacturer recommendations, these connections must prevent rotation or misalignment of the signal head as well as misalignment between sections. The serrated circular connection shall contain a total of 72 teeth. The serrated area shall start at the outside of the 2-inch hole. The serrated area shall be at least ⅛-inch wide. The teeth shall have a minimum depth of 3/64-inch between peaks and valleys. The teeth shall be well-defined; free from burrs, irregularities, or other imperfections; and provide positive locking with the grooves of mating sections, framework, and brackets. The serration on the top circular connection of a signal section shall have a valley at the 0-degree position, aligned perpendicular to the front of the section. The serration on the bottom circular connection shall have a peak at the 0-degree position, aligned perpendicular to the front of the section. Connections shall permit the assembly of a multi-section signal with the front of each section aligned within one degree. Signal sections shall include latch pads and manual stainless steel latching devices that are captive, or non-removable. Signal sections shall have at least two latching points.

All hardware, such as hinge pins, door latching devices and washers, screws and fittings shall be constructed of stainless steel type 316 or 304. Wire attachment screws used on terminal blocks may be fabricated using other non-corrosive material, but must be approved by the FDOT.

Provide four backplate mounting attachment points located on the sides of each signal section. The backplate attachment points shall be no more than three inches from each signal section corner. The backplate attachment points shall be designed to accept #10-16 x 3/8 inch or 10-24 x 3/8 inch screws for securing backplates.

Each signal section shall be designed to prevent the accumulation of standing water within the assembly.

Washers between signal sections (such as those used with tri-stud fasteners) shall be 3/32-inch minimum thickness.

Washer distortion of more than 1/16-inch will not be allowed when assemblies and attachment hardware are fastened together. Washers shall be constructed of stainless steel type 316 or 304. All sections comprising a single multi-section vehicular signal assembly shall be rigidly and securely fastened together to form a dust and insect resistant, weather tight unit.

A650-2.2 Assembly - 8 inch Emergency Signal Heads

Emergency signal heads are not allowed for use at intersections and are only allowed at Fire Stations or other locations that warrant the use of an emergency signal. Emergency signal heads shall meet all requirements listed in this specification with the following exceptions.

- The lens diameter shall be within 7.75 to 8 inches.
- Minimum Visor length of 7 inches.
- Circular lenses shall be 8 inches in diameter.
- Light Center Length: 2 7/16 inches.
- Rated Initial Lumens: No less than 595 Lumens.
- Maximum Wattage: 60 W.

A650-2.3 Doors

Each signal section shall include at least two integral hinges of adequate strength for mounting the door. Hinge pins must be captive. Signal sections shall include doors that can be mounted to provide either left or right swing. The door shall be held tightly closed with stainless steel (type 316 or 304) locking devices. The door must remain captive and secure at all times. The inside face of the door shall be provided with at least four stainless steel, type 316 or 304, lens gasket clamps for securing the lens to the door. The door shall include slotted pads that allow the door to be opened and closed by engaging or disengaging the latching device. The outside face of the door shall include four holes equally spaced around the circumference of the lens opening to accommodate the attachment of a visor. The outside face of the door shall provide a light-tight seal between the visor and the door assembly. The lens opening in the door shall have a diameter of 11 to 11.5 inches.

A650-2.4 Visors

The rear of the visor shall have four tabs, notches or holes for securing the visor to a signal section door. The visor mounting method shall permit the visor to be rotated and secured at 90 degrees for horizontal signal head installations. All visors shall have a minimum downward tilt of 3.5 degrees measured from the center of the lens. Visors shall have a minimum length of 9.5 inches. Tunnel visors shall encircle and shield the lens from 300 degrees, plus or minus 10 degrees. Louvers may only be used in combination with Full Circle visors. The use of louvers with tunnel visors is prohibited.

A650-2.5 Gaskets

Signal head sections shall include gaskets that provide a weatherproof seal to prevent the intrusion of dust and moisture into the signal assembly. Provide seals between the body of the signal section assembly and door, between the lens and the door, between lens and reflector, and between any other mating surfaces where gaps may allow intrusion of dust and moisture. Gaskets shall be glued or sealed, where they meet, to provide one continuous length of gasket. Gasket materials shall be constructed of weather resistant material that has been temperature stabilized to prevent any residue that could collect on the internal surfaces of the signal head.

A650-2.6 Backplates (Standard and Retroreflective)

The top, bottom, and sides of all backplates shall measure from five to six inches in width. All backplates shall include louvers. No louvers shall be closer than ½ inch from the inner or outer edge of the backplate panel. Louver orientation shall be vertical on sides and horizontal on top and bottom.

All backplate outside corners shall be rounded.

All backplates shall be provided with a minimum of four corner mounting attachment points per signal section (i.e., a three-section signal assembly would have 12 mounting points). Backplates must not interfere with the operation of traffic signal section doors.

All backplates shall include stainless steel screws, washers, and other installation hardware required to mount the backplate securely to a signal assembly. Hardware must meet the requirements of Section 603 of the SSRBC.

All backplates shall be dull black (Federal Standard 595A-37038) with a reflectance value not exceeding 25 percent as measured by ASTM E1347. Polycarbonate backplates shall be constructed of ultraviolet stabilized polycarbonate.

Aluminum backplate minimum thickness shall be 0.060 inch. All aluminum backplates shall be powder coated in accordance with A650-5.3.

Polycarbonate backplate minimum thickness shall be 0.120 inch.

Backplate thickness measurement shall not include the retroreflective sheeting thickness. Retroreflective backplates shall be constructed of aluminum.

Universal backplates must fit all FDOT approved traffic signals.

A650-2.6.1 Retroreflective Borders:

Retroreflective borders shall be constructed from a 2 inch yellow retroreflective adhesive sheeting border on the entire outer perimeter of the backplate panels.

Retroreflective sheeting type shall be Yellow, Type III or Type IV and listed on the FDOT's Qualified Products List (QPL).

The retroreflective border shall be placed no closer than ½ inch from all louvers. No sheeting is allowed over any louvered area.

A650-3 Light Emitting Diode (LED) Optical Unit (State Standard)

The LED Optical Unit shall conform to the requirements of the latest LED Purchase Specification of the Institute of Transportation Engineers (ITE), "Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Circular Signal Supplement" with the following exceptions:

A650-3.1 Physical and Mechanical Requirements

Retrofit LED Signal Modules shall be compatible with currently approved traffic signal housings. The manufacturer's name, model number, date of manufacturing, serial number and other necessary identification shall be permanently marked on the rear of the LED signal module. The LED signal module shall be marked with a label that includes the FDOT Certification Number once the device has been approved.

A650-3.2 LED Signal Module Lens

The lens shall be tinted with an appropriate color (red, amber or green) to reduce sun phantom affect and enhance on/off contrast. The tinting shall be uniform across the face of the lens, free from streaks, wrinkles, chips, bubbles, or other imperfections. If a polymer lens is used, a surface coating shall be incorporated to provide abrasion resistance.

A650-3.3 Electrical

Electrical conductors for LED signal modules shall be a minimum of 36 inches in length. Each lead from the LED module shall be terminated with insulated slide-on terminals. The conductors shall be color coded to identify the color of the module as follows: White shall identify the neutral lead. Red circular signals shall be identified with a red lead, yellow circular signals with a yellow lead, and green circular signals with a green lead. Red arrows shall be identified with a red & black tracer lead, yellow arrows with a yellow and black tracer lead and green arrows with a green and black tracer lead.

A650-3.4 Minimum Maintained Luminous Intensity Values—VTCSH LED Circular Signal

Red and Green modules shall meet the current requirements of Performance Specification of the Institute of Transportation Engineers (ITE), Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Circular Signal Supplement, June 27, 2005. Yellow modules shall be 1.7 times brighter than the aforementioned ITE specification.

A650-4 Terminal Blocks

A minimum of (one) five-connection terminal block shall be provided in all three section signal head assemblies. A minimum of three, five-connection terminal blocks shall be provided in all five section signal head assemblies. Terminal block connections in the signal assembly shall not require any tools other than a screwdriver.

A650-5 Material and Construction Requirements

A650-5.1 Color of Signal Heads

The housing, door, and visor color shall be dull black (Federal Standard 595A-37038) with a reflectance value not exceeding 25 percent as measured by ASTM E1347. For polycarbonate heads the black color shall be incorporated into the plastic material before molding.

A650-5.2 Polycarbonate Signal Housings and Visors

The assembly and door shall be molded from ultraviolet stabilized polycarbonate plastic with a minimum thickness of 0.1 ± 0.01 inches. The plastic formulation used shall provide the following physical properties in the assembly (tests may be performed on separately molded specimens).

Tests, Requirements, and Methods:

- Specific Gravity, 1.17 minimum, ASTM D 792
- Vicat Softening Temp., °F (°C); 305-325 (152 - 163); ASTM D 1525
- Brittleness Temp., °F (°C); Below -200 (-129); ASTM D 746
- Flammability, Self-extinguishing, ASTM D 635
- Tensile Strength, yield, PSI (MPa); 8500 (58) minimum; ASTM D 638
- Elongation at yield, %; 5.5 - 8.5; ASTM D 638
- Shear, strength, yield, PSI (Mpa); 5500 (38) minimum; ASTM D 732
- Izod impact strength, ft-lb/in (j/m) [notched, 1/8 inch]; 15 (800) minimum; ASTM D 256
- Fatigue strength, PSI (MPa) at 2.5 mm cycles; 950 (6.5) minimum; ASTM D 671

Visors shall be constructed of the same material specified for the assembly and door.

A650-5.3 Powder Coating

Aluminum signal heads shall be pretreated for painting with a base metal preparation of the entire head assembly to prevent normal deterioration by environmental conditions. Surface erosion, flaking, or oxidation shall not occur within the normal life expectancy under typical installation conditions in Florida. All interior and exterior aluminum surfaces of the signal head assembly including visors, door and housing shall be powder-coated in accordance with Military Standard MIL-PRF-24712A or AAMA-2603-02. The finish shall meet the requirements of ASTM D 3359, ASTM D 3363, and ASTM D 522. The manufacture shall provide powder-coating procedures and specifications to the FDOT for review and approval.

A650-5.4 Identification and Warranty

All signal components shall be marked with the device serial number and other information required in Section A601. Manufacturers shall replace or repair LED signal modules that fall below minimum intensity levels within the first 60 months of field operation. The manufacturer shall warrant signal modules, backplates, and any other signal assembly components against fading, cracking or peeling for a minimum three year period. The manufacturer shall replace defective components during the warranty period within thirty days of notification from the FDOT.

SECTION A653
PEDESTRIAN SIGNAL ASSEMBLY

A653-1 Description

This section specifies the minimum requirements for the certification of pedestrian signals. Pedestrian signal assemblies shall also meet the requirements of the latest edition of the Federal Highway Administration’s (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) and the Institute of Transportation Engineers (ITE) standard for Pedestrian Traffic Control Signal Indications.

A653-2 Housing and Visor

The housing shall be constructed of a non-corrosive material. Cast metal parts shall have a minimum tensile strength of 17 ksi (117 MPa) and sheet metal parts a minimum tensile strength of 27 ksi (186 MPa). If other alloys are used, the alloy shall have one of the following compositions:

> ***Die castings:*** The alloy shall be in accordance with American Society for Testing and Materials (ASTM) B 85. The physical characteristics and chemical content shall be within the combined limits established by alloys S-12A, S-12B, C-84A, SC-84B, SG-1OOA and SG-1OOB of the ASTM specification.
>
> ***Sand Castings:*** The alloy shall be in accordance with ASTM B 26. The physical characteristics and chemical content shall be within the combined limits established by alloys S5A and CS72A of the ASTM specification.
>
> ***Permanent mold castings:*** The alloy shall be in accordance with ASTM B 108 or the latest revision thereof. The physical characteristics and chemical content shall be within the combined limits established by alloys S5A and CS72A of the ASTM specification.
>
> ***Polycarbonate:*** The material shall conform to the requirements of Section A650.

The housing shall be of unitized sectional construction and may consist of as many sections as optical units. No light shall be able to escape from one unit to the other. The housing shall have mounting areas on the top and bottom, consisting of a round opening for a 1.5-inch ID pipe, allowing the signal assembly to be rotated between the mounting brackets or trunnions for directing in various angles in the horizontal plane. The housing shall include a positive locking serrated fitting to prevent the faces from rotating with orientation in increments not exceeding five degrees of rotation.

Mounting points and adjacent housing material shall be reinforced. Unused openings shall be closed with a waterproof closure and painted to match the housing. The door encompassing the lens shall be hinged and held securely to the housing. Mildew-proof gaskets (ASTM D 1056, Grade SBE42 or approved equivalent) shall be provided between the housing and door and between the lens and door. A gasket between the housing and door may be omitted if the fitting between the housing and door does not permit the entrance of rain or dust. A gasket between the lens and door may be omitted if the lens is tempered glass or of high-impact polycarbonate and the fitting between the lens and door does not permit the entrance of rain or dust.

Each signal face shall have a visor. The visor shall not permit any infiltration of light between the door and visor. The visor shall be three-sided and extend a minimum of 7 inches at the top from the face of the lens. The visor shall be noncorrosive sheet metal, not less than 0.05 inch thick, (No. 18 gauge in thickness) or polycarbonate.

The door, housing, and visors of metal heads shall be powder-coat painted in accordance with Military Standard MIL-PRF-24712A or AAMA-2603-02. The color shall be black with a reflectance value not exceeding 25 percent as measured by ASTM E97.

For polycarbonate heads, the black color shall be incorporated into the material before the molding process. All hardware (pins, screws, hinges, latches, studs, washers, etc.) shall be stainless steel type 316 or 304.

A653-3 Light Emitting Diode (LED) Pedestrian Signal Optical Unit (State Standard)

LED pedestrian signals shall conform to the requirements of the latest ITE LED Pedestrian Signal Specifications of the ITE.

For inclusion on the FDOT's Approved Product List, proof of conformance to the above requirements by an independent testing shall be furnished to the FDOT. This proof of conformance shall state pass/fail criteria and results for each test conducted on the device.

A653-4 Electrical

Each signal shall be wired with color-coded #18 American Wire Gauge (AWG), or larger, stranded wires. The wiring shall have an approved 600 V outdoor insulation rating or equivalent. Wires shall be a minimum of 3 feet long with self-insulating slide-on terminals. No bare wiring shall be exposed where wires are secured.

Each pedestrian signal shall be fitted with a terminal block in the bottom sections containing a minimum of three circuits, each with two noncorrosive screw-type terminals. Each terminal shall be able to accommodate three No. 18 AWG conductors and shall be labeled for ease of identification. The terminal block shall not be obstructed and be visible when the housing is open.

A653-5 Pedestrian Head Mounting Hardware

All trunnions, brackets, and suspensions used in mounting pedestrian signals to concrete, steel, aluminum, or wood poles shall be an aluminum alloy cast fitting, pipe or equivalent as approved by the FDOT. This alloy shall have a minimum tensile strength of 35 ksi (240 MPa) in accordance with ASTM B 221 or ASTM B 26.

All screws, studs, washers, etc., shall be stainless steel type 316 or 304. All mounting hardware shall be painted black with a reflectance value not exceeding 25 percent as measured by ASTM E 97.

SECTION A659
SIGNAL HEAD AUXILIARIES

A659-1 Description

This section specifies the minimum requirements for the certification of signal head auxiliaries used in the construction of a signalized intersection.

A659-2 Supports and Attachments

The signal heads shall be equipped with devices or means for positive locking with supporting hardware, which will prevent any rotation or misalignment caused by strong winds or any objects which might come into contact with the signal head.

All trunnions, brackets and suspensions required for assembling and mounting the pedestrian and traffic signals shall be entirely weather-tight.

All fastening devices, such as bolts, nuts, washers, etc., shall be stainless steel type 316 or 304. All cable shall be stainless steel type 316 or 304 only.

Threaded ends, such as with mast arm bracket attachment cables, shall be stainless steel as specified above. The cable end shall be constructed to be held at one end with a wrench to prevent rotation while removing the nut.

A659-3 Tri-Stud Serrated Adjustable Drop Hanger

The adjustable hanger shall be constructed of aluminum alloy Almag 35 (535.0) having a minimum tensile strength of 35 ksi (240 MPa) and meet all standards, including chemical composition and material mechanical properties, in accordance with American Society for Testing and Materials (ASTM) B 26 specifications. The adjustable hanger shall be constructed to support the wind load and weight of any combination of signal indications with disconnect hangers and back plates, etc.

Extension bracket bars shall be made from T6061-T6 extrusion aluminum alloy with a minimum tensile strength of 38 ksi (262 MPa) in accordance with ASTM B 221.

The bottom of the adjustable hanger shall have an integral serrated boss that will provide positive positioning of the disconnect hangar in 5-degree increments so as to eliminate any rotation or misalignment. A total of 72 teeth shall be provided in the serrated boss. The serrated area shall be flush with the outside bottom surface. It shall be at least 1/8 inch wide and 3/64 inch deep. The teeth shall be clean and sharp so as to provide positive positioning with the teeth of the disconnect hanger. The connection between the teeth of the disconnect hanger and adjustable hanger shall be waterproof. This may be accomplished by means of a thin neoprene or other weather resistant gasket.

The span wire clamp pin attachment hole on the top of the adjustable hanger shall have a stainless steel bushing (or sleeve) to eliminate wear of the attachment hole.

Suspensions for mast-arm mounting or span-wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

A659-4 Drop Pipe Hangers

Drop pipe hangers shall be galvanized 1.5-inch steel or 1.5-inch T6061-T6 aluminum alloy with a minimum tensile strength of 43 ksi (297 MPa) in accordance with ASTM B 221 specifications. The drop pipe shall have national pipe thread (NPT) on each end for assembly.

A659-5 Brackets

The top and bottom brackets used in the assembly of multi-directional signals and mast arm brackets shall be constructed of aluminum alloy 319.0 having a minimum tensile strength of 23 ksi (158 MPa) and meet all standards, including chemical composition and material mechanical properties, in accordance with ASTM B 26 specifications.

The top bracket shall be hollow, with a cross-sectional diameter of at least 1.5 inch I.D. for receiving the signal wires. It may be constructed either of one hollow rectangular cast piece or of hollow "pieced" round tubing. The wall thickness shall be at least 3/16 inch. Each top bracket (2-way, 3-way, and 4-way) shall have a 2-inch diameter hole in the top side of the casting for receiving a 38 mm entrance fitting. The underside of the top bracket shall have a hole of at least 3 inches in diameter with suitable cover for the installation of the signal wires.

The bottom bracket shall be of one-piece solid construction and shall hold the signal heads firmly in place. The top and bottom openings of the top bracket which mate with the adaptor hub and signal heads shall have an integral serrated boss that will provide positive positioning of the signal head in 5-degree increments so as to eliminate any rotation or misalignment of the signal head. A total of 72 teeth shall be provided in the serrated boss. The serrated area shall be flush with the outside of the 2-inch hole; it shall be at least 1/8 inch wide and 3/64 inch deep. The teeth shall be clean and sharp so as to provide positive positioning with the teeth of the signal head or adaptor hub. The connection between the teeth of the signal head and adaptor hub with the brackets shall be waterproof. This shall be accomplished by FDOT-approved sealant (clear or black in color). All connections of the bracket shall be of the tri-stud design.

A659-6 Disconnect Hangers

The disconnect hanger shall be constructed of the same material as specified for brackets (Section A659-5). Signal heads which are to be mounted on span wire or on a mast arm shall be provided with a disconnect hanger which will facilitate the removal of the signal head from the mounting attachment with or without the use of tools and without disconnecting or disturbing the wiring leads entering the signal head assembly. Signal heads that mount on mast arms by bands/brackets or cables, such as "Astro-Brac" or equivalent, will not require the use of a disconnect hanger as part of the assembly.

The disconnect hanger shall be supplied with the following items:

- Wired terminal strip rated at 600 V AC (RMS) with adequate circuits (12 minimum) to handle the required signal circuits. The terminal strip shall be easily accessible for connection of the field wiring. The terminal strip shall be of such a design that the signal cable insulation can be stripped and the signal wire inserted into the appropriate circuit and compressed by tightening the terminal compression screw.

For quick disconnect capability, the disconnect shall be supplied with the following:

- A 12-circuit (minimum) female socket rated at 600 V AC (RMS) shall be mounted in the disconnect hanger.
- The 12 pin socket shall be wired to the terminal strip in the disconnect hanger.
- A 12-circuit (minimum) harness assembly rated at 600 V AC (RMS) with a male plug to mate with the socket shall be mounted in the disconnect hanger. The harness shall be no less than 42 inches (1.07 m) long and will be used to connect the signal lamps in the signal head to the respective circuits in the disconnect hanger.
- Each wire shall be numbered to correspond with the terminal block number.

For the above connection, 12 pin Cinch Jones plugs may be used. Other quick disconnect plugs may be used if approved by the FDOT.

An adapter hub shall be provided to attach the signal head assembly to the disconnect hangar. The adaptor hub shall be constructed of aluminum alloy Almag 35 (535.0), having a minimum tensile strength of 35 ksi (240 MPa), and meet all standards, including chemical composition and material mechanical properties in accordance with ASTM B 26 specifications. The adapter hub shall be supplied with tri-stud connections and have the same serrated boss design as the bracket specified above.

The adaptor hub shall be secured with integrally cast wedges on the housing and the door of the disconnect hangar. In addition, a one-piece aluminum hold down device of sufficient strength shall be mounted on the inside bottom of the disconnect housing, across the entire adapter hub, to hold the adapter hub securely in place, to prevent any movement, rotation or misalignment of the signal head.

The adapter hub shall be secured in the disconnect hangar and shall not allow any rotational movement of the signal head assembly.

Each signal cable entrance of the disconnect hanger shall be provided with a medium density, weatherproof, neoprene closed-cell split grommet tube. The tubes are to be inserted in each disconnect cable entrance. Each tube shall be a minimum of 3 inches long. This tube shall be removable and reusable under normal maintenance activities. The tube shall provide protection from rain and animal access into the disconnect housing, and also protect the cable from chafing against the cable entrance. Other methods to accomplish this may be used if approved by the FDOT. Plastic shipping caps are not acceptable for this use.

The top of the disconnect hanger shall have a 2-inch opening with an integral serrated area to interface with the adjustable hanger as specified above, or an optional 1.5-inch NPT threaded top section for drop pipe installation. This optional top section shall provide a positive locking device to prevent signal head rotation or misalignment.

A door gasket shall be provided as part of the disconnect hanger and shall be secured to the disconnect hanger housing or door. The disconnect hanger door shall swing open to the side using stainless steel hinge pins Type 304 or 316. The thumbscrew holding the door to the housing shall be stainless steel in accordance with Section A601 and shall be non-removable (captive).

A659-7 Painting

The disconnect hanger (interior and exterior), tri-stud adaptor hub, and other attachments, except for the adjustable drop hanger and the span wire clamp, shall be powder-coat painted in accordance with Military Standard MIL-PRF-24712A or AAMA-2603-02. Finish must meet ASTM D 3359, ASTM D 3363, and ASTM D 522. The color shall be dull black (Federal Standard 595A-37038) with a reflectance value not exceeding 25 percent as measured by ASTM E 97.

A659-8 Other Requirements for Brackets and Hardware

All finished castings be shall have a smooth finish free from cracks, blow-holes, shrinks, and other flaws. All brackets disconnect hangars, tri-stud adjustable hangers and adapter hubs, and any other attachments shall have the manufacturer’s name or trademark, part number, and FDOT Certification Number permanently affixed on the device for identification, in accordance with Section A601.

Minimum Specifications for Traffic Control Signals and Devices
Section A659 Signal Head Auxiliaries

Submittal packages for signal head auxiliaries must include an independent laboratory report certifying that the chemical composition, alloy, and material mechanical properties meet these specifications, ASTM B 26 or ASTM B 221 specifications, along with current Aluminum Association Standards.

SECTION A660
INDUCTIVE LOOP DETECTOR

A660-1 Description

This section specifies the minimum requirements for the certification of inductive vehicle loop detectors that are used in combination with sensor loops imbedded in the roadway surface to detect vehicles. This section also specifies the requirements for loop wire, lead-in cable and sealant materials.

An inductive loop detector unit is an electronic device that energizes sensor loops, monitors the sensor loop's inductance and responds to a predetermined decrease in inductance with an output which indicates the passage or presence of vehicles.

A660-2 Classification of Types

A channel is defined as electronic circuitry which functions as a detector unit.

- Single channel, shelf-mounted detector units powered from 120 V AC:
    - A Type 1 detector unit shall have a relay output.
    - A Type 2 detector unit shall have a relay output with time delay features.
    - A Type 3 detector unit shall have a solid state output.
    - A Type 4 detector unit shall have a solid state output with time delay features.
- Two channel, shelf-mounted detector units powered from 120 V AC:
    - A Type 5 detector unit shall have relay outputs.
    - A Type 6 detector unit shall have relay outputs with time delay features.
- Four channel, shelf-mounted detector units powered from 120 V AC:
    - A Type 7 detector unit shall have relay outputs.
    - A Type 8 detector unit shall have relay outputs with time delay features.
- Two channel, rack-mounted detector units powered from external 24 V DC source:
    - A Type 9 detector unit shall have solid state outputs.
    - A Type 10 detector unit shall have solid state outputs with time delay features.
- Four channel, rack-mounted detector units powered from external 24 V DC source:
    - A Type 11 detector unit shall have solid state outputs.

A Type 12 detector unit shall have solid state outputs with time delay features.

A660-3 Operational Requirements

The inductive loop vehicle detector unit described in these specifications shall respond to change in the inductance of the sensor loop/lead-in combinations connected to its loop input terminals. It shall develop a detection output when there is a sufficiently large decrease in the magnitude of the connected inductance. The sensor loops connected to the detector unit input terminals shall be located at the intended detection zones. The sensor loops shall be connected to the detector unit by means of a lead-in cable. The sensor loops shall be so configured that the presence of a vehicle in each zone of detection causes a sufficient decrease in inductance to cause an output response from the detector unit.

A660-3.1 Power Inputs

AC+ (line side): The protected side of the 120 V AC 60 Hz power source. The steady state input current per channel shall not exceed 100 mA RMS.

AC- (common): The unfused and unswitched return side, neutral of the 120 V AC 60 Hz power source. This input shall not be connected to LOGIC GROUND or CHASSIS GROUND within the unit, or to the loop input terminals.

+24 V DC: Supplies power for DC units. The current consumption shall not exceed 100 mA per channel. The return for this input is LOGIC GROUND.

A660-3.2 Logic Ground

Logic ground is the return for +24 V DC. This point shall not be connected within the unit to AC- (common) or to CHASSIS GROUND, or to any loop input terminal.

A660-3.3 Chassis Ground

The loop detector unit shall have a terminal for connection to the chassis of the unit. This input shall not be connected to LOGIC GROUND, AC- (common), or to any other point within the unit, except that it shall be permissible to use this input as a return for transient protection devices.

If the unit has a metallic case, the case shall be connected to CHASSIS GROUND.

A660-3.4 Electrical Properties

Each channel of the detector unit shall function according to the requirements of this specification and shall operate without significant degradation with any sensor loop/lead-in combination which exhibits the following electrical properties as measured at the detector unit terminals of the lead-in: (Ref. NEMA TS-2 Specifications, Section 6.5.2.11)

a) Inductance at 50 kHz- 50 to 700 μH.
b) Q at 50 kHz- greater than five.
c) Resistance to earth ground greater than 1 Megohm. (Ref. 6.5.2.11 of TS-2 specification).

A660-3.5 Tuning

Each detector channel shall include a means for accommodating the range of sensor loop/lead-in inductance.

A660-3.6 Self Tuning

The unit shall tune automatically upon the application of power. It shall achieve normal operation and at least 90 percent of its selected sensitivity within three minutes after application of power.

A660-3.7 Self Tracking

The detector unit shall automatically accommodate those after-tuning changes in the loop/lead-in electrical characteristics as might reasonably be expected to occur in undamaged loops, properly installed in sound pavement and exhibiting the electrical properties outlined above for loop/lead-in electrical properties without producing a false output or change in sensitivity.

A660-3.8 Power Interruption

After a power interruption longer than 20 ms, the detector unit shall resume normal operation with at least 90 percent of its selected sensitivity within three minutes after the main supply voltage recovers to a voltage within the specified limits.

A660-3.9 Crosstalk

Each detector channel shall include means to prevent that channel from adversely interacting with any other channel. The means to prevent such interaction shall be inherent, automatic or manual.

A660-3.10 Controls and Indicators

All controls and indicators necessary for the operation of the detector unit shall be located on the front panel of the unit except as noted below. Multiple functions combined in a single control shall be permitted. These include, but are not limited to, the following:

Output Indicator: Means to visually indicate the output state of each channel. Each channel shall have a separate indicator.

Sensitivity Control: Means to permit selection of the sensitivity of each channel.

Overcurrent Protection Device: Required for AC-powered units. If the overcurrent protection device on an AC-powered unit is a fuse or circuit breaker, it shall be accessible from the front panel. Internal mounting of any other overcurrent protection device will be permitted.

Manual Tuning Control: When required, permits accommodation of the range of loop/lead-in inductances.

Reset: A control which unconditionally causes the detector or detection channel to retune to a non-vehicle present condition.

Mode Selector: Means to permit selection of pulse or presence mode operation of each channel. Card mounting of this control shall be permitted on card rack units.

Crosstalk Control: As required, provides means to prevent interaction of channels as described above. Card mounting of this control shall be permitted on card rack units.

A660-3.11 Relay Outputs:

a) Contacts closed-indicate detection output.
b) Power outage or overcurrent failure condition contacts closed indicate detection output.
c) Output circuit isolation
   1) Resistance of 1 Megohm minimum
   2) Breakdown of 1 kV RMS minimum
d) Contact rating (resistive load)
   1) Two mA through 1 A at 18 to 28 V
   2) 0.5 A at 120 V AC
   3) Maximum closed contact resistance of 1 ohm
e) Mounting-plug-in with socket or direct solder mounting.
f) Minimum operations
   1) 1,000,000 with contacts at rated load
   2) 10,000,000 total mechanical

A660-3.12 Solid State (Isolated) Outputs:

a) Output solid state device-conducting indicates detection output.
b) Power outage or overcurrent failure condition-output device is nonconductive indicating a no detection output condition.
c) Output circuit isolation
   1) Resistance 1 Megohm minimum
   2) Breakdown 1 kV rms minimum
d) Output rating – the output shall conduct a minimum of 20 mA with a maximum 1.4 V drop across the output terminals.

e) Transition time – when switching to or from a steady state current in the range of 2.4 to 20 mA, the transition time from 6 to 16 V and vice versa shall be 0.1 ms or less. The circuit(s) to which the output is connected is defined in Section A671 (controller unit inputs).
f) Maximum voltage – hold off 30 V DC minimum under non-detect conditions.

A660-3.13 Time Delay Features

Detector units with time delay features shall be provided with an electronic internal timing feature which delays and extends the closure of the output relay for an adjustable minimum time period of 0 to 30 seconds after a vehicle enters the zone of detection of the sensor loop(s).

After expiration of the delay time, the detector unit shall activate its output.

If vehicle presence is shorter than the delay time, the timer shall reset.

An input shall be provided to allow an external 120 V AC signal to inhibit the time delay feature (set the time delay to zero seconds).

A660-3.14 Sensitivity

Each channel of the detector unit shall include means to adjust the sensitivity such that it will not produce an output when the nearest point of a vehicle is 36 inches or more outside the loop perimeter. A minimum of three sensitivity selections shall be provided for each detection channel.

A660-3.15 Performance Standards

All detector units shall be designed to meet or exceed the following performance standards:

Test Loop Configuration: Sensor loop and lead-In combinations used to verify the performance requirements of detector units shall consist of the following combinations of 6-by-6 foot (1.8-by-1.8 m), three-turn loops and shielded lead-in cable.

a) Single-loop 6-by-6 foot (1.8-by-1.8 m), three turns with 100 feet (30 m) of lead-in (80-105 µH).
b) Single-loop 6-by-6 foot (1.8-by-1.8 m), three turns with 1000 feet (300 m) of lead-in (260-320 µH).
c) Four loops 6-by-6 foot (1.8-by-1.8 m), three turns in a row in the direction of travel and separated by 9 feet (2.7 m), series/parallel-connected with 250 feet (75 m) of lead-in (110-140 µH).

Test Vehicle Definition: Detector units shall detect all vehicles which ordinarily traverse the public streets and highways and which are comprised of sufficient conductive material suitably located to permit recognition and response by the detector system. Vehicles are classified in accordance with the reduction in inductance resulting when they are centered in the single 6-by-6 foot, three-turn test loop with 100 feet of lead-in described above. These minimum reductions are as follows:

a) Class 1 0.12 µH (small motorcycle)
b) Class 2 0.3 µH (large motorcycle)
c) Class 3 3.0 µH (automobile)

The maximum reduction caused by any test vehicle shall be five microhenries.

Approach Speed: The detector unit shall detect any vehicle described above over any of the single loops described above, traveling within the speed range of 5 to 80 mph.

The detector unit shall detect any vehicle described above over all of the loops of the four-loop configurations described above, traveling within the speed range of 5 to 20 mph.

All channels of a multi-channel detector shall operate at the same sensitivity and be connected to equivalent inductances for the purpose of these tests.

Modes of Operation: Each detector channel shall be capable of functioning in the following two front panel selectable modes:

a) Presence – When a Class 2 vehicle (0.3 µH) or a larger vehicle occupies the center of any of the test loops, the detector shall be capable of maintaining a detection output for a minimum of three minutes.
b) Pulse – A detection output between 75 and 150 ms shall be initiated when a vehicle enters the sensor loop zone of detection.

If this vehicle remains in the zone of detection, the detector shall become responsive within a maximum of four minutes to additional test vehicles entering the zone of detection.

The detector shall produce only one output pulse for a test vehicle traveling at 10 mph across the zone of detection of the single sensor loops.

Recovery from Sustained Occupancy: When operating in the presence mode, and following a sustained occupancy of five minutes, the detector unit shall recover to normal operation with at least 90 percent of the sensitivity within one second after the zone of detection is vacated.

When the detector unit is operating in the presence mode and a Class 1 and Class 3 vehicle are centered over any of the loops of the four-loop configurations, the detector unit shall continue to detect the Class 1 vehicle after the Class 3 vehicle leaves the detection zone of the loop that it was centered over.

Response Time: When operating in the presence mode, the detector unit shall be capable of being set to produce an output in response to a 0.12 μH step decrease in inductance (equivalent to the minimum decrease from a Class 1 vehicle) within not more than 125 ms when tested on either of the single loop test configurations. In response to a step return to the original inductance, the detector shall terminate its output within not more than 125 ms.

When operating in the presence mode, the detector shall be capable of being set to produce an output in response to a 3 μH step decrease in inductance (equivalent to the minimum decrease from a Class 3 vehicle) within not more than 50 ms when tested on either of the single loop test configurations. In response to a step return to the original inductance, the detector shall terminate its output within not more than 50 ms. All channels of a multi-channel detector shall be operating at the same sensitivity and connected to equivalent inductances for the purpose of these tests.

A660-3.16 Power Supply

Power supplies for use with Types 9 through 12 detector units, when required, shall be powered from 120 V AC. The output of the power supply shall be 24 V DC ±2.5 V with a minimum current rating of 1 A. The power supply shall be designed for mounting in a rack. The power supply module shall be provided for pulling and inserting the power supply in the card rack. The power supply shall be provided with an overcurrent protection device. The maximum supply ripple shall not exceed 500 mV peak to peak.

A660-3.17 Input / Output Connectors

Types 1 and 2 Detector Units: The chassis connector of the detector unit shall mate with an MS3106-A-18-1S cable connector. Pin terminations shall be as follows:

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Section A660 Inductive Loop Detector

Pin	Function
A	AC – (Common)
B	Output (-)
C	AC + (line side)
D	Loop input
E	Loop input
F	Output (+)
G	Reserved
H	Chassis Ground
I	Reserved
*J	Inhibit time delay feature

*Required for Type 2 detector units.

Types 9, 10, 11, and 12 Detector Units: Types 9, 10, 11, and 12 detector units shall mate with a 44 terminal, double row, 0.156 inch contact spacing, card edge connector 50-44A-30M. Pin terminations shall be as follows:

Pin	Function
A	Logic ground
B	+24 V DC supply
C	Reserved
D	Loop input, Ch 1
E	Loop input, Ch 1
F	Output, Ch 1 (+)
H	Output, Ch 1 (-)

Pin	Function
*1	Inhibit time delay, Ch 1
*2	Inhibit time delay, Ch 2
**3	Inhibit time delay, Ch 3
4	Redundant loop input,Ch1
5	Redundant loop input,Ch1
6	Spare
7	Spare

J	Loop input, Ch 2	8	Redundant loop input,Ch2
K	Loop input, Ch 2	9	Redundant loop input,Ch2
L	Chassis ground	**10	Inhibit time delay, Ch 4
M	Reserved	11	Reserved
N	Reserved	12	Reserved
P	Loop input, Ch 3	13	Redundant loop input,Ch3
R	Loop input, Ch 3	14	Redundant loop input,Ch3
S	Output, Ch 3 (+)	15	Spare
T	Output, Ch 3 (-)	16	Spare
U	Loop input, Ch 4	17	Redundant loop input,Ch4
V	Loop input, Ch 4	18	Redundant loop input,Ch4
W	Output, Ch 2 (+)	19	Spare
X	Output, Ch 2 (-)	20	Spare
Y	Output, Ch 4 (+)	21	Spare
Z	Output, Ch 4 (-)	22	Spare

* Required for Types 10 & 12 detector units.
** Required for Type 12 detector units.

Polarization keys shall be located at three positions:

- Between B/2 and C/3
- Between M/11 and N/12
- Between E/5 and F/6

Types 9 and 10 detector units shall have no connections to pins P, R, S, T, U, V, Y, Z, 13, 14, 17, and 18.

Connector Harness Assembly: The connector harness assembly for Types 1 through 12 detector units shall include the appropriate cable connector, cable clamp and bushing, and wire. The wire shall be a minimum of #22 AWG stranded copper with a 600 V thermoplastic insulation. All wire shall be at least 60 inches long and bundled together with the use of cable ties every 4 inches or other approved method. The wires shall be color and/or number coded.

A660-3.18 Mechanical Requirements

The maximum dimensions of detector units are specified below: (W=width, H=height, D=depth)

Types 1 and 2 detector units:
W= 2.5 inches, H= 7 inches, D= 9 inches (including projections, but excluding the mating connector)
Types 5, 6, 7 and 8 detector units:
W= 3.5 inches, H= 7 inches, D= 9 inches (including projections, but excluding the mating connector)
Types 9 and 10 detector units (refer to Figure A660-1):
W= 1.14 inches, H= 4.5 inches, D= 7 inches (excluding the handle)
Types 11 and 12 detector units (refer to Figure A660-2):
W= 2.31 inches, H= 4.5 inches, D= 7 inches (excluding the handle)

Connectors: On shelf-mounted detector units (Types 1 through 8) all inputs and outputs including power shall enter the unit through a front panel connector. The connectors of shelf-mounted units shall mate with the connectors specified above.

Accessibility: All detector units shall be easily disassembled to gain access for maintenance. When disassembled, the detector shall be operational for troubleshooting. Rack mounted detectors shall be supplied with a handle for extracting the unit out of the detector rack card cage.

Components: All printed circuit boards shall be coated in a similar manner and made from NEMA (FR- 4) glass-epoxy, flame retardant, or equivalent (*See* current edition of NEMA Standards Publication LI 1, Industrial Laminated Thermosetting Products). Circuit boards exceeding 2 inches in any dimension shall be at least 1/16 inch nominal thickness. Circuit boards not exceeding 2 inches in any dimension shall be at least 1/32 inch nominal thickness.

The walls of all plated-through holes shall have a minimum copper plating thickness of 0.001 inch (25 µm). All circuit tracks shall have a conductivity equivalent to at least one ounce per square foot (305 g/m2) of copper. All electrical mating surfaces shall be made of non-corroding material.

The unit shall be designed so that each component is identified by a circuit reference symbol. This identification shall be affixed to the printed circuit board(s), the cover of the unit, or in an assembly drawing provided with the unit.

The housing for Types 1 through 8 detector units shall be constructed of durable material which will withstand falling from a height of approximately 8 feet (2 m) onto a concrete pad.

Types 9 through 12 detector units shall be provided with a rack and mounting hardware.

A660-3.19 Environmental Requirements

All detector units (Types 1 through 12) shall operate in accordance with these specifications when subjected to the following environmental conditions specified in Section A615:

a) A615-2 – Operating voltage and frequency, except for Types 9 through 12 detector units, the voltage range shall be 24 ±2.5 V DC with a maximum supply ripple of 500 mV peak to peak.
b) A615-4 – Temperature and humidity
c) A615-5 – Vibration
d) A615-6 – Shock

AC Power Interruption: For all detector units – two or more power interruptions, which are separated by power restorations of 1500 ms or more, shall be considered as separate interruptions. The detector units shall react to the power interruptions as follows:

a) Three interruptions of 20 ms or less which are separated by power restorations of 300 ms (or more) shall not cause the loop detector unit to revert to its start-up sequence.
b) The loop detector unit shall be permitted to revert to its start-up sequence following power interruptions longer than 20 ms.

Transients: Detector units shall operate in accordance with these specifications when subjected to the transient levels specified below.

AC power inputs: Types 1 through 8 detector units only: transient levels as described in Section A615-7.1.

DC power inputs: Types 9 through 12 detector units only: transient level as described in Section A615-7.2.

Loop input terminals: (These requirements apply to each channel, types 1 through 12 detector units) Transient level shall be as described in Section A615-7.3, except the voltage shall be 200 V; the loops shall not be connected; and power shall be applied to the detector unit. Each detector loop input terminal shall be subjected to ten transient pulses of each polarity between the loop terminal and chassis ground with the other loop terminal ungrounded and repeated with the other terminal connected to chassis ground. Voltage on the capacitor shall be adjusted to 3000 V ± 5 percent. This test shall be performed with the detector unit operating from its normal power source and with a 100 μH ± 10 percent coil connected across the loop terminals of each channel.

A660-4 Materials

A660-4.1 Loop Wire

Loop wire shall conform to the following requirements:

a) Wire size #14 or #12 AWG, stranded copper with a minimum of seven strands.
b) XHHW insulation rated for 600 V.
c) The wire shall be surface-printed indicating the manufacturer ID and its NRTL listing (UL, CSA, etc.), the maximum rated voltage, AWG size, the proper type letter or letters for the type of wire or the International Municipal Signal Association (IMSA) specification number every 2 feet (0.6 m) or less.

A660-4.2 Lead-In Cable

Lead-in cable shall conform to IMSA Specification 50-2 along with the following requirements:

a) Twisted pair, shielded and jacketed construction.
b) Each conductor of the twisted pair shall be insulated with polyethylene. The insulation color of one conductor shall be black; the other conductor shall not be black.
c) The wire size of each conductor shall be #12 thru #18 AWG stranded copper with a minimum of 19 strands.
d) The voltage rating of the polyethylene insulation shall be 600 V.

e) The twisted pair shall be covered with an aluminum-polyester shield which provides 100 percent shield coverage.
f) A stranded copper drain wire shall be in contact with the shield. The drain wire used shall be two gauge sizes less than the conductor gauge size.
g) A continuous polyethylene jacketed cable shall cover the shield and drain wire. The outer jacket insulation shall have a minimum average thickness of 0.030 inches.
h) The outer jacket shall be surface printed indicating the manufacturer ID and its NRTL listing (UL, CSA, etc.), the maximum rated voltage, AWG size, the proper type letter or letters for the type of wire or the IMSA specification number every 2 feet (0.6 m) or less.

A660-4.3 Splicing Material

Splicing material shall conform to the following requirements:

a) Butt-end connectors may be used for splicing the loop wire to the lead-in cable. Butt-end connectors shall be non-insulated, Panduit Part Number BS14, BS10; Ideal Model Number TV16X, TV12X; Thomes and Betts Catalog Number BB-2, CC-2 or District Traffic Operations Engineer- (DTOE) approved equivalent.
b) Solder shall be resin-core type.
c) Silicone tape shall be Scotch 70, Plymouth "Physil," or DTOE-approved equivalent.
d) Insulated tubing shall be heat-shrinkable, cross-linked polyethylene with a silicon sealant inside the tubing. The tubing shall have an insulation rating of at least 600 V.

SECTION A665
PEDESTRIAN DETECTOR

A665-1 Description

This section specifies the minimum requirements for the certification of pedestrian detectors. The components of the pedestrian detector are the pushbutton housing, pushbutton, pushbutton sign, electrical/wiring, post and riser, mounting hardware and lead-in wire.

A665-2 Pushbutton Assembly

The assembly shall meet the following Americans with Disabilities Act (ADA) requirements: Controls (buttons) shall be raised from or flush with their housings and shall be a minimum of 2 inches in the smallest dimension. The force required to activate controls shall be no greater than 5 pounds$_f$ (22.2 N).

The assembly shall be weather-tight and tamper resistant and shall be so designed and constructed that it will be impossible to receive an electrical shock from touching the assembly under any weather condition.

A665-2.1 Housing

The assembly housing shall be a sturdy two piece unit consisting of a base housing and a removable cover. The internal components shall provide a pushbutton with normal open contacts and shall include all electrical and mechanical parts required for operation. The housing shall be cast aluminum which meets Section A653. Hardware for attaching cover to back housing shall meet the requirements of Section 603 of the SSRBC. The housing or an adapter (saddle) shall conform to shape of pole, fitting flush to assure a rigid installation. Saddles shall be of the same material and construction as the housing. Pushbuttons for wood pole mounting shall have threaded holes for ½-inch (size 16) conduit provided in the housing top or bottom for any necessary conduit attachment and shall be serviced by a conduit riser. Unused openings shall be closed with a weatherproof closure and painted to match the housing. Pushbuttons mounted on steel poles shall be serviced by wiring inside the pole. A ¾-inch hole with an insulated bushing shall be provided through the back of the housing. Unused holes shall be plugged as described above. Pushbuttons mounted on concrete poles shall be serviced by a conduit riser or by wiring inside the pole (same as steel pole). Pushbuttons mounted on top of a post shall be provided with a slip fitter and screws for securing rigidly to post.

The complete body of the housing shall be powder-coat and painted in accordance with Military Standard MIL-PRF-24712A. The color of the housing shall be black and the housing shall be marked in accordance with Section A601.

A665-2.2 Pushbutton

The pushbutton switch shall be a mechanical phenolic enclosed, positive-acting, spring-loaded, snap-action switch with single pole, single throw contacts or Piezo driven solid state switch. The switch, when activated, shall give an audible indication of actuation (i.e., click). Pig-tail type connections are allowed. Screw type terminals may be used as long as no binding of the wiring occurs once the device is installed, using the correct gauge of wire. The switch shall have a design life of one million operations (minimum) at rated load.

A665-2.3 Pushbutton Sign

A pedestrian instructional sign shall be furnished with each pushbutton assembly and shall be of the size and legend specified on the plans. The sign shall be a minimum thickness of 0.07-inch steel sheeting with baked enamel legend and background or 0.88-inch aluminum sheeting with painted legend and background.

A665-2.4 Electrical Requirements

The pushbutton assembly shall be rated for a minimum of 50 V. The wiring shall be No. 18 AWG stranded (minimum) with 600 V outdoor insulation rating. The assembly shall include all lead-in wire.

A665-2.5 Post and Riser

The conduit riser, when required for external routing of the lead-in wire, shall be ½-inch NPT galvanized steel pipe with threading for attachment to the pedestrian detector-housing. Posts when required for mounting pedestrian detector assemblies shall be nominal pipe size 2.5 inch O.D. aluminum pipe.

SECTION A670
TRAFFIC CONTROLLER ASSEMBLY

A670-1 Description

This section specifies the minimum requirements for the certification of NEMA and 170E traffic controller assemblies and flashing beacon assemblies.

A670-2 Actuated Solid State Controller Assembly

An actuated solid state controller assembly shall consist of a digital timed controller, load switches, a flasher, a conflict voltage monitor and other equipment wired into a controller cabinet to make a complete operational traffic controller assembly, as specified in the specifications.

A670-2.1 Controller

The digital timed controller shall conform to the requirements of Section A671.

A670-2.2 Load Switches and Transfer Relays

The load switches and transfer relays shall conform to the requirements of Section A678.

A670-2.3 Flasher

The flasher shall be a Type 3 as specified in Section A678.

A670-2.4 Conflict Voltage Monitor

The conflict voltage monitor shall conform to the requirements of Section A678. The type of conflict voltage monitor to be furnished is specified below:

Controller Specified	Conflict Voltage Monitor Required
D4-4, D8	12 or 18

Model 170E conflict voltage monitor shall be a Model 210 conflict monitor with the absence of red monitoring.

A670-2.5 Controller Cabinet

The NEMA controller cabinet shall conform to the requirements of Section A676-1 through A676-9.

Type 170 controller cabinet shall conform to the requirements of Section A676-10 and 676-11.

A670-2.6 Coordinated Features

A coordination unit shall be included as part of the controller assembly and shall conform to the requirements of Section A671. The type of controller cabinet to be furnished is specified below:

Controller Specified	Coordination Unit Specified	Controller Cabinet Required
D4-4, D8	DMI, DSI	5

A670-3 Flashing Beacon Controller Assembly

A flashing beacon controller assembly shall consist of a Type 3 flasher (Section A678), wired into a Type 1 controller cabinet (Section A676) to make a complete and operational traffic controller assembly.

SECTION A671
TRAFFIC CONTROLLER

A671-1 Description

This section specifies the minimum requirements for the certification of traffic signal controllers, NEMA and Type 170.

Terminology utilized in this section is consistent with that utilized in the traffic control equipment industry. For the most part, terminology utilized to specify traffic operational features and equipment features are supportive and not contradictory; however, certain terms (such as the word "phase") have traditionally been utilized to describe both operational and equipment features in a slightly different manner. In the case of such differences, the meaning of such terms as is traditional within the traffic control equipment industry and NEMA shall govern in this section.

A671-1.1 Classification of Types

Type D4-4 controller units are actuated, dual ring containing four sequentially timed and individually selected conflicting phases per ring. The rings are arranged to allow concurrent timing of phases in both rings, subject to the restraints of the interlock barrier.

Type D8 controller units are actuated, single ring containing eight sequentially timed and individually selected conflicting phases.

TS 2 Type 1 controller units utilize a high-speed data channel between all major equipment. T.S. 2-Type 2 controller retains the MSA, MSB, and MSC connectors for data exchange with the load panel as specified in Section A676. The T.S. 2 series controller is covered in NEMA STANDARDS PUBLICATIONS NO. TS 2.

TS 2 Type 2 controller units, with the exception of the TS 2 series controller internal coordinator, shall be interoperable with the same manufacturer’s TS 1 controller internal coordinator as specified in Section A671-20.

TS 2 series controllers shall be National Transportation Communication ITS Protocol-compatible. Type 170 controllers are covered at the end of this specification.

A671-1.2 Environmental Requirements

All traffic controller units shall be designed to meet the environmental requirements specified in Section A615.

A671-1.3 Documentation

Documentation, as specified in Section 603 of the SSRBC, shall be provided with all controller units.

A671-1.4 Phase

Types D4-4 and D8 controller units shall be provided with the following features on a per phase basis:

A671-1.4.1 Inputs:

Vehicle detector call: Used to enter a vehicle demand for service into the appropriate phase of the controller unit.

Pedestrian detector call: Used to enter a pedestrian demand for service into the appropriate phase of the controller unit.

Hold: Used to retain the existing right-of-way and cause different controller responses depending upon operation in the non-actuated or actuated mode.

For a non-actuated phase-activation of the HOLD, input shall maintain the controller unit in the timed out WALK period with a GREEN and WALK indication displayed. Activation of the HOLD input, while timing the WALK portion of the GREEN interval, shall not inhibit the timing of this period. Activation of the HOLD input with the WALK interval timed out shall cause the controller unit to advance into the PEDESTRIAN CLEARANCE interval. Re-application of the HOLD input, while timing the PEDESTRIAN CLEARANCE portion of the GREEN interval, shall neither inhibit the timing of this period nor cause termination of the phase.

For an actuated phase-activation of the HOLD, input shall allow the controller unit to time normally, but shall inhibit its advance into the vehicle clearance interval. Deactivation of the HOLD input shall inhibit the recycle of the pedestrian service unless the PEDESTRIAN RECYCLE input is active and a serviceable pedestrian call exists on the phase. The rest state signal indications for the phase shall be GREEN for traffic and DON'T WALK for pedestrians.

Deactivation of HOLD input shall allow the controller unit to advance into the GREEN DWELL/SELECT state when all green periods are timed out. Deactivation of HOLD input with all intervals timed out shall allow the controller unit to recycle the WALK interval if there is no conflicting demand for service and a pedestrian call exists for that phase. However, if there is any serviceable demand on an opposing phase with the HOLD input deactivated, and with all intervals timed out, the controller unit shall advance into the vehicle clearance interval and not recycle the WALK on that phase until those demands have been served.

Phase omit: Used to inhibit the selection of a phase, even if the phase has a vehicle and/or pedestrian demand for service. The phase committed shall not present a conflicting call to any other phase, but shall accept and store calls.

Pedestrian omit: Used to inhibit the selection of a phase due to a pedestrian call on that phase and to prohibit the servicing of a pedestrian call on that phase. Activation of this input shall not affect a pedestrian movement in the process of timing.

A671-1.4.2 Outputs:

Load switch drivers, basic vehicle: (3 per phase) Used to energize the appropriate vehicle signal load switching circuit to result in a GREEN, YELLOW, or RED output. A circuit closure to logic ground shall be maintained on one of the three outputs at all times.

Load switch drivers, pedestrian: (3 per phase) Used to energize the appropriate pedestrian signal load switching circuit to result in a WALK, PEDESTRIAN CLEARANCE, or DON'T WALK indication. The DON'T WALK output shall flash only during the PEDESTRIAN CLEARANCE interval. A circuit closure to logic ground shall be maintained on one of the three outputs at all times.

Check: Used to indicate call status (vehicle and/or pedestrian) of the phase and shall be active when the controller unit is in a non-green interval, subject to demand on that phase. The PHASE OMIT or PEDESTRIAN OMIT inputs shall not affect the CHECK output.

Phase on: Used to indicate phase status. The PHASE ON output of a phase shall be active during the GREEN, YELLOW and RED CLEARANCE intervals of that phase. The PHASE ON output may be active during the RED REST (DWELL) state.

Phase next: Used to indicate when the phase is committed to be next in sequence and remains energized until the phase becomes active.

A671-1.5 Ring

Types D4-4 and D8 controller units shall be provided with the following features on a per ring basis:

A671-1.5.1 Inputs:

Force-off: Used for termination of the GREEN timing and/or WALK-HOLD (State B) in non-actuated mode of the active phase in the timing ring subject to the presence of a serviceable conflicting call. The FORCE-OFF function shall not be effective during the timing of the INITIAL, WALK or PEDESTRIAN CLEARANCE intervals. The FORCE-OFF input shall be effective only as long as the input is sustained.

Red rest: Used to force the controller to rest in RED interval of all phases by continuous application of an external signal. Registration of a serviceable conflicting call shall result in immediate advance from RED REST to GREEN of the demanding phase. Registration of a serviceable conflicting call before entry into the RED REST state, even with this signal applied, shall result in termination of the active phase and selection of the next phase in the normal manner and with appropriate changes and clearances.

Inhibit maximum termination: Used to disable the maximum termination functions of all phases in the selected timing ring. The input shall not inhibit the timing of MAXIMUM GREEN.

Omit red clearance: Used to omit red clearance interval timing(s).

Pedestrian recycle: Used to control the recycling of the pedestrian movement. The recycling operation is dependent on whether the phase is operating in the actuated or non-actuated mode. When the phase is operating in the actuated mode, if a serviceable pedestrian call exists on the phase and the HOLD input is active, the pedestrian movement shall be recycled when the PEDESTRIAN RECYCLE input is active, regardless of whether a serviceable conflicting call exists. When the phase is operating in the non-actuated mode, if the phase has reached State D, the PEDESTRIAN OMIT is not active on the phase and a serviceable conflicting call does not exist, the pedestrian movement shall be recycled when the PEDESTRIAN RECYCLE input is active.

Stop timing: Used to cause cessation of controller unit ring timing for the duration of such activation. Upon removal of activation from this input, all portions which were timing will resume timing. During stop timing, vehicle actuation on non-GREEN phases shall be recognized; vehicle actuation shall reset the PASSAGE TIME timer in normal manner; and the controller unit shall not terminate any interval or interval portion or select another phase, except by activation of the INTERVAL ADVANCE Input. Operation of the INTERVAL ADVANCE with STOP TIMING activated shall clear any stored calls on a phase when the controller unit is advanced through the green interval of that phase.

Maximum II (selection): Used to select the second maximum time setting on all phases of the timing ring.

Outputs:

Coded status bits A, B and C.

Bit Logic States

Code No	C	B	A
0	+24 V	+24 V	+24 V
1	+24 V	+24 V	0 V
2	+24 V	0 V	+24 V
3	+24 V	0 V	0 V
4	0 V	+24 V	+24 V
5	0 V	+24 V	0 V
6	0 V	0 V	+24 V
7	0 V	0 V	0 V

Only one of the coded status codes listed above shall be active when the following conditions are present in the controller unit.

*The active phase is in its Green interval and operating in the actuated mode.

Code 0-Minimum Timing: When timing the INITIAL, WALK or PEDESTRIAN CLEARANCE portions of the GREEN interval.

Code 1-Extension Timing: That portion of the GREEN interval following the completion of the minimum timings (INITIAL, WALK and PEDESTRIAN CLEARANCE) when timing an extension(s).

Code 2-Maximum Timing: That portion of the GREEN interval following the completion of the minimum timings (INITIAL, WALK and PEDESTRIAN CLEARANCE) when not timing an extension and the MAXIMUM GREEN is timing (e.g., when the HOLD input is active).

Code 3-Green Rest: That portion of the GREEN interval when the minimum timings (INITIAL, WALK and PEDESTRIAN CLEARANCE) are complete; PASSAGE TIMER is timed out and the MAXIMUM GREEN timer is either timed out or has not started.

*The active phase is in its GREEN interval and operating in the non-actuated mode.

Code 0-Walk Timing: When timing the WALK portion of the GREEN interval (non-actuated State A).

Code 1-Walk Hold: When the WALK output is active, WALK timing is complete and the HOLD input is active (non-actuated State B).

Code 2-Pedestrian Clearance Timing: When timing the PEDESTRIAN CLEARANCE interval or the remaining portion of MINIMUM GREEN (non-actuated State C).

Code 3-Green Rest: When the timing of PEDESTRIAN and MINIMUM GREEN intervals are complete (non-actuated State D).

*The active Phase is not in its GREEN interval.

Code 4-Yellow Change: When timing YELLOW CHANGE.

Code 5-Red Clearance: When timing RED CLEARANCE.

Code 6-Red Rest: When timing is complete and a RED indication is displayed.

A671-1.6 Unit

Types D4-4 and D8 controller units shall be provided with the following features on a per unit basis:

A671-1.6.1 Inputs:

AC + (line side): Fused side of 120 V AC 60 Hz power source.

AC - (Common): Unfused and unswitched return side of 120 V AC 60 Hz power source taken from neutral output of AC power source. This input must not be connected to LOGIC GROUND or CHASSIS GROUND within the controller unit.

Chassis ground: Terminal for connection to the chassis of the unit. CHASSIS GROUND shall be electrically connected to the shell of the connector(s) where applicable. This input shall not be connected to LOGIC GROUND or AC - (Common) within the controller unit.

Interval advance: A complete ON-OFF operation of this input shall cause immediate termination of the interval in process of timing. Where concurrent interval timing exists, use of this input shall cause immediate termination of the interval which would terminate next without such actuation. Phase without stored vehicle or pedestrian calls shall be omitted from the resultant phase sequencing of the controller unit unless EXTERNAL MIN. RECALL TO ALL PHASES or MANUAL CONTROL ENABLE inputs are activated. The controller unit shall select the next phase to service based on its normal sequence control method. If INTERVAL ADVANCE is activated during the GREEN interval and no serviceable call exists, the controller unit shall not advance beyond the GREEN DWELL/SELECT state, except when RED REST is active. If INTERVAL ADVANCE is applied when the controller unit is displaying GREEN and WALK indications, the unit shall advance to the state of displaying GREEN and PEDESTRIAN

CLEARANCE. IF INTERVAL ADVANCE is applied when the unit is displaying GREEN and PEDESTRIAN CLEARANCE, the unit shall display a steady DON'T WALK indication and advance to the GREEN DWELL/SELECT state, from which it shall immediately select a phase next and advance to the YELLOW, subject to the presence of a serviceable conflicting call and the constraints of concurrent timing. If no pedestrian provisions exist, application of the INTERVAL ADVANCE signal at any point in the GREEN interval shall cause the unit to advance to the GREEN DWELL/SELECT state from which it shall immediately select a phase next and advance to the YELLOW, subject to the presence of a serviceable conflicting call and the constraints of concurrent timing.

Manual control enable: Used to place vehicle and pedestrian calls on all phases, stop controller unit timing in all intervals except vehicle clearance intervals, and inhibit the operation of INTERVAL ADVANCE during vehicle clearance intervals. When this function is used in conjunction with INTERVAL ADVANCE, the operation of the controller unit shall be as follows:

- When concurrent pedestrian service is not provided, one activation of the INTERVAL ADVANCE shall advance the controller unit to GREEN DWELL/SELECT, from which it shall immediately select a phase next and advance to the YELLOW, subject to the constraints of concurrent timing.
- When concurrent pedestrian service is provided, two sequential activations of the INTERVAL ADVANCE input shall be required to advance through a given GREEN interval. The first actuation shall terminate the WALK interval; the second shall terminate the GREEN interval, including the PEDESTRIAN CLEARANCE interval.
- All vehicle clearance intervals are timed internally by the controller unit. Actuation of the INTERVAL ADVANCE input during vehicle clearance intervals shall have no effect on the controller unit.

Call to non-actuated mode (2 per unit): Two inputs shall be provided which, when activated, shall cause any phase(s) programmed to operate in the NON-ACTUATED MODE (only phases equipped for pedestrian service shall be used for NON-ACTUATED MODE operation). The inputs shall be designated CALL TO NON-ACTUATED MODE I and CALL TO NON-ACTUATED MODE II. The actuated phases that are converted to NON-ACTUATED operation by activation of either of the CALL TO NON-ACTUATED MODE inputs shall have a permanent demand placed for vehicle and pedestrian service.

External minimum recall: Used to place a recurring demand on all vehicle phases for a minimum vehicle service.

Indicator lamp control: Used to disable controller unit indicators. Controller units which use light emitting diode (LED) or liquid-crystal display (LCD) or other solid state semiconductor displays do not have to be furnished with this input.

Test input (2 per unit): For manufacturer's use only.

External start: Used to force the controller to revert to its start-up sequence. Upon removal of this input the controller unit shall commence normal timing.

Walk rest modifier: Used to modify non-actuated operation only. With this input active, non-actuated phase(s) shall remain in the timed out WALK state (Rest in WALK) in the absence of a serviceable conflicting call without regard to the HOLD input status. With this input non-active, non-actuated phase(s) shall not remain in the timed out WALK state unless the HOLD input is active. The controller unit shall recycle the pedestrian movement when reaching State D in the absence of a serviceable conflicting call.

A671-1.6.2 Outputs:

Logic ground: Voltage reference point and current return for controller unit input and output logic circuits. This output must not be connected to AC- (Common) or CHASSIS GROUND within the controller unit.

Controller unit voltage monitor: An open collector output which is maintained TRUE (low state) only as long as the voltages within the controller unit do not drop below predetermined levels required to provide normal operation.

Regulated 24 volts for external use: Positive 24 ± 2 V DC, regulated over an AC line voltage variation from 95 to 135 V and from no-load to full-load. Current capacity shall be 500 mA continuous with less than 0.5 V peak-to-peak ripple.

Flashing logic output: Alternating true/false logic output at 1 pulse per second repetition rate with 50 percent, ± 2 percent duty cycle. In its FALSE state, this output shall be capable of providing 50 mA of current. In its TRUE state, this output shall be capable of sinking 200 mA. This output shall switch within five degrees of the zero crossover point of the AC line.

Load switch drivers, vehicle overlap (3 per overlap): Used to energize the appropriate overlap signal load switching circuit to result in a GREEN, YELLOW or RED output. A circuit closure to logic ground shall be maintained at one of the three outputs at all times unless internal 4-section, left turn, logic is provided.

A671-1.7 Assignment of Right of Way

Right-of-way shall not be given to any phase without presence of a call. In complete absence of calls, the right-of-way shall remain in the green interval on the phase where it was last assigned. These provisions are subject to the following exceptions:

Recall mode: The right-of-way can be assigned to any phase programmed for recall.

Red rest: When programmed, the controller unit shall rest in the red interval for all phases.

Call to non-actuated mode: When active, phase programmed for non-actuated mode shall be assigned to the right-of-way.

If a call exists for several phases, the controller unit shall assign the right-of-way in accordance with the preferential phase sequence requirements. The rest position of a phase shall be in the green interval, subject to absence of conflicting calls and red rest input is not active.

Dual ring controller units (Type D4-4) shall operate in the dual entry mode in which one phase in each ring must be in service. When a call does not exist in a ring when the controller unit crosses the barrier, a phase shall be selected to be active as indicated below:

- If a left turn movement (1, 3, 5, and 7) has a call, then the concurrent through-movement (6, 8, 2, and 4) on the other ring shall be selected.
- If a through movement (2, 4, 6, and 8) has a call, then the concurrent through-movement (6, 8, 2, and 4) on the other ring shall be selected.

A671-1.8 Transfer of Right of Way

The transfer of right-of-way from any phase shall take place only after the green interval has timed at least the minimum green interval.

The transfer of right-of-way from any phase shall take place immediately if there has been no actuation on that phase for more than one passage time interval prior to a call on the opposing phase.

Should transfer of right-of-way occur with no passage time remaining, a call shall not be placed for that phase.

Should transfer of right-of-way occur, while a passage time interval has not completed timing or upon expiration of the maximum green interval, a vehicle call shall automatically be placed for that phase, except when the vehicle detection memory is in the non-lock mode.

Detector actuation on phases that do not have the right-of-way shall initiate maximum green timing circuit of the phase with the right-of-way.

At the expiration of the green interval, by either gaping out or reaching maximum time, the right-of-way shall be transferred to the phases that have a call.

The transfer of right-of-way from any phase shall consist of a yellow clearance interval and an all red clearance interval, unless the contract documents specifically call for a different operation.

When transferring the right-of-way in a dual ring controller (Type D4-4) from the major street to the minor street, or vice versa (i.e., across the barrier), both phases shall yield the right-of-way simultaneously, regardless of which phase was last to find a gap in excess of the allowable gap or to have the maximum green terminate. The phase that first finds a gap in excess of the allowable gap or terminates its maximum green interval shall remain in the green interval until the other phase also finds a gap in excess of the allowable gap or terminates its maximum green interval.

When a pedestrian interval is timing, transfer of right-of-way shall not take place during the walk or clearance interval. Transfer of right-of-way shall take place only during the don't walk interval.

A671-1.9 Actuation Requirements

The actuation of a detector on any phase while the right-of-way is on a conflicting phase shall, after the proper passage time interval and clearance interval, cause the right-of-way to be transferred to the phase from which the actuation was received, subject to phase omit and pedestrian omit inputs.

Actuation of a vehicle detector during the extendable portion of a green interval shall initiate the timing of one passage time interval.

Successive detector actuation spaced less than the allowed passage time extension interval in effect shall retain the right-of-way, but not longer than the programmed maximum green interval when a conflicting call is present.

Actuation of a pedestrian detector during a pedestrian clearance interval, or at any other time which the pedestrian DON'T WALK signal is being displayed, shall register the presence of said pedestrian. This actuation shall be stored so that the pedestrian WALK interval will be accorded at the next opportunity in the normal sequence of the controller, subject to the pedestrian omit input.

Successive actuation of the pedestrian detector shall not cause extension of the pedestrian walk interval.

With a vehicle-pedestrian or pedestrian call, the vehicular green interval shall consist of at least the sum of pedestrian walk and clearance interval.

When the controller is in the rest position and a pedestrian actuation is received on the phase that is in the rest position, and there are no conflicting pedestrian or vehicular calls, the controller shall recycle and provide pedestrian walk and clearance intervals.

Actuation of a vehicle detector during the clearance interval of a phase shall automatically place a vehicle call for that phase, except when the vehicle detector memory is in the non-lock mode.

A671-1.10 Phase Intervals

Green internal-actuated phase:
Without volume density: The GREEN interval is a variable interval dependent upon vehicle actuation. The GREEN interval time shall commence timing limited by the MAX GREEN time function which shall commence timing upon registration of a serviceable conflicting call. The MINIMUM GREEN time shall not be preempted by a MAX GREEN termination. Three time settings shall be provided for determination of GREEN timing on an actuated phase without volume density:

- MINIMUM GREEN – The first timed portion of the GREEN interval.
- PASSAGE TIME (PRE-SET-GAP) – The extensible portion of the green shall be a function of vehicle actuations that occur during the green interval. The phase shall remain in the extensible portion of the green interval as long as the passage timer is not timed out.
- MAXIMUM GREEN – This time setting shall determine the maximum length of time this phase may be held GREEN in the presence of an opposing serviceable call. In the absence of a serviceable conflicting call, the MAXIMUM GREEN timer shall be held reset.

With volume density: In addition to MINIMUM GREEN, PASSAGE TIME, and MAXIMUM GREEN timing functions, phases provided with VOLUME DENSITY operation shall include VARIABLE INITIAL timings and GAP REDUCTION timings. The effect on the INITIAL timing shall be to increase the timing in a manner dependent upon the number of vehicle actuations stored on this phase while its signal is displaying yellow or red. The effect on the extensible portion shall be to reduce the allowable GAP between successive vehicle actuations by decreasing the extension time in a manner dependent upon the time waiting of vehicles on an opposing RED phase.

- VARIABLE INITIAL – The variable initial timing period shall be determined by an interrelationship of two time settings as follows: MINIMUM GREEN setting shall determine the minimum variable initial time period. SECONDS/ACTUATION setting shall determine the time by which the variable initial time period will be increased from zero with each vehicle actuation received during the associated phase YELLOW and RED intervals. The maximum of the variable initial timing period shall be fixed at 30 seconds, or shall be able to be set (on a per phase basis) in the range of 0-60 seconds with increments of one second. Maximum variable initial setting shall be subordinate to MINIMUM GREEN time setting. Initial timing shall equal seconds/actuation, multiplied by the number of actuations within the constraint of MAXIMUM INITIAL and shall not be less than MINIMUM GREEN.
- GAP REDUCTION – The gap reduction function shall be accomplished by means of the following functional settings: time before reduction, passage time, minimum gap, and time to reduce.

  The time before reduction period shall begin when the phase is Green and there is a serviceable conflicting call. If the serviceable conflicting call is withdrawn while timing this period, the timer shall be reset and remain reset until the next serviceable conflicting call is received. Upon completion of the time before reduction period, the linear reduction of the allowable gap from the passage time level shall begin. The rate of reduction shall be based on the setting of the PASSAGE TIME, MINIMUM GAP, and TIME TO REDUCE controls. This method shall reduce the allowable gap at a rate equal to the difference between the PASSAGE TIME and MINIMUM GAP settings divided by the setting of the TIME TO REDUCE control. The reduction of the allowable gap shall continue until the gap reaches a value equal to or less than the minimum gap as set on the MINIMUM GAP control after which the allowable gap shall remain fixed at the value set on the MINIMUM GAP control. In the presence of a continuous vehicle actuation, the phase shall not gap out even if the GAP is reduced to zero (i.e., MINIMUM GAP set at zero).

  If at any time the serviceable conflicting call is withdrawn, the gap shall revert to the PASSAGE TIME setting value and time BEFORE REDUCTION period timer shall be reset and remain reset until the next serviceable conflicting call is received.

Pedestrian Timing-Concurrent:
Concurrent pedestrian timing shall be permitted in association with any mode of vehicle signal timing. Two time settings shall be required:

- WALK – Shall control the amount of time the WALK indication shall be displayed.

- PEDESTRIAN CLEARANCE – Shall control the duration of the PEDESTRIAN CLEARANCE output and the flashing period of the DON'T WALK output.

When a pedestrian call is stored in pedestrian memory and pedestrian indications are concurrent with an associated vehicle phase, the pedestrian sequence shall commence service when entering the vehicle GREEN of that phase unless the PEDESTRIAN OMIT line is activated. During indication of the WALK and PEDESTRIAN CLEARANCE intervals, a concurrent GREEN vehicle indication shall be shown. It shall be possible to recycle the pedestrian indications in response to succeeding pedestrian calls for service, subject to absence of serviceable conflicting calls (vehicle or pedestrian) and non-activation of the PEDESTRIAN OMIT line.

Actuated phase operating in non-actuated mode:
The actuated phases that are converted to NON-ACTUATED operation by activation of either of the CALL TO NON-ACTUATED MODE inputs shall have a permanent demand placed for vehicle and pedestrian service. Each such phase shall be equipped with pedestrian timing capability.

These phases shall be considered to have the four green states as indicated below:

- State A shall be the minimum timing state. The duration of State A shall be equal to the WALK time setting. Signal indications for State A shall be GREEN and WALK.
- State B shall be a state immediately following the minimum timing state. The controller unit shall dwell in this state in the presence of a HOLD signal or when the WALK REST MODIFIER is active and no serviceable conflicting call exists. The signal indications shall remain in GREEN and WALK. The controller unit shall leave this state when the HOLD input is not active or when the HOLD input is active, a serviceable conflicting call exists, and the FORCE-OFF input is activated. If the phase HOLD is active and the FORCE-OFF is activated when the phase is active and a serviceable conflicting call does not exist, the controller unit shall continue to dwell in State B of the phase.
- State C shall be the PEDESTRIAN CLEARANCE state. During State C, the phase shall activate to the PEDESTRIAN CLEARANCE output and flash the DON'T WALK output. The duration of the state shall be equal to the PEDESTRIAN CLEARANCE setting. The phase shall time the clearance and advance to State D upon completion of the timing.
- State D shall be a GREEN DWELL SELECT state from which the controller unit may select the next phase(s) to be serviced. During State D, signal indications shall be GREEN and steady DON'T WALK. When a serviceable conflicting call does not exist, and the PEDESTRIAN RECYCLE input is active, or when a serviceable conflicting call does not exist and the WALK REST MODIFIER is active, the phase shall return to State A and re-time the WALK interval. If the PEDESTRIAN RECYCLE input is not active,

and the WALK REST MODIFIER is not active, the pedestrian movement shall not recycle.

In the presence of external signals used for coordination, the sequence of these states shall be as follows:

- The GREEN interval begins with the existence of State A. Upon the completion of this state the controller unit exits to State B. If the HOLD input is active at this point, the controller unit shall remain in this state. If FORCE OFF is applied and if a serviceable conflicting call exists, the controller unit shall advance to State C; otherwise State B exists as long as HOLD remain active. If HOLD is released while the controller unit is in State B, the controller unit shall advance to State C without regard to the presence of a serviceable conflicting call. If the controller unit advances to State C, it shall advance to State D even in the presence of HOLD. When in State D, the controller unit shall terminate the phase if a serviceable conflicting call exists. If no serviceable conflicting call exists and if PEDESTRIAN RECYCLE is active, the controller unit returns to State A of this interval. If PEDESTRIAN RECYCLE is not active and no serviceable conflicting call exists, the controller unit resets in State D .The HOLD function has no effect on the duration of State D.
- The duration of the GREEN interval shall not be less than the setting of the MINIMUM GREEN control. In those instances where the sum of the WALK setting, the HOLD state duration and the PEDESTRIAN CLEARANCE setting is less than the setting on the MINIMUM GREEN control, the controller unit shall remain in State C and shall display a steady DON'T WALK until the phase has displayed a GREEN indication for a time equal to the MINIMUM GREEN time setting.

Green Timing Termination:
Green timing termination shall occur in response to one of the following conditions:

- INTERVAL ADVANCE when timing the last portion of the green interval.
- INTERVAL ADVANCE with MANUAL CONTROL ENABLE activated.
- The initial green and the pedestrian service completed with a serviceable conflicting call, or RED REST activated with any one of the following: 1) PASSAGE TIME timed out or the reduced gap timed out without HOLD applied; 2) MAXIMUM GREEN termination without HOLD applied; or, 3) FORCE OFF applied.

Vehicle Clearance Intervals:
Following the GREEN interval of each phase, the controller unit shall provide a YELLOW CLEARANCE interval which is timed according to the YELLOW CLEARANCE timing control for that phase.

Following the YELLOW CLEARANCE interval for each phase, the controller unit shall provide a RED CLEARANCE interval which is timed according to the RED CLEARANCE timing control for that phase. During this RED CLEARANCE interval, no GREEN indication shall be shown to any conflicting phase. This RED CLEARANCE interval is subject to omission in response to operation of the per ring OMIT RED CLEARANCE input. RED REVERT, an adjustable (2 to 6 seconds) minimum RED indication, will be timed following the YELLOW CLEARANCE interval and prior to the next display of GREEN on the same phase. The RED REVERT time shall not be less than two seconds and shall not be adjustable in increments greater than one second.

Exclusive Pedestrian Timing:
No other phase of the controller unit shall be active (green) when an exclusive phase is being serviced.

Type D4-4 (dual ring) controller units shall not require more than two phases in the second timing ring when EXCLUSIVE PEDESTRIAN timing is employed in the other timing ring, neither of which can be employed on the same side of the barrier with the EXCLUSIVE PEDESTRIAN phase.

When a pedestrian call is stored in pedestrian memory, the exclusive pedestrian phase shall be serviced with appropriate consideration of its order in the priority of phase sequencing.

The exclusive pedestrian phase shall rest with a steady DON'T WALK indication displayed. It shall be possible to recycle the pedestrian indications in response to succeeding pedestrian calls for service, subject to absence of serviceable conflicting calls (vehicle or pedestrian) and non-activation of the PEDESTRIAN OMIT line.

Exclusive pedestrian movements shall be considered as a phase in Types D4-4 and D8 controller units.

A671-1.11 Ring Configuration

The required number of rings and phases per ring for D4-4 and D8 controller units are specified below:

Type of Controller	Number of Phases Per Ring	Number of Rings
D4-4	4	2
D8	8	1

A671-1.12 Preferential Sequence

With calls on all phases, the preferential sequence for Types D4-4 and D8 controller units shall be as indicated in Figure A671-1. If one more phases do not have a call, or are not used, then the sequence shall be as above, but shall skip those phases without calls.

A671-1.13 Start-Up Sequence

Upon restoration of power, a vehicle call (as a minimum) shall be placed on all phases. The start-up sequence shall be programmable to start at the beginning of the green or yellow interval of any selected phase or non-conflicting phase pair. Unless otherwise stipulated in the contract documents, the start-up sequence shall begin with the major street (movements 2 and 6) green interval and serve in preferential sequence; all phases with at least a minimum recall or the summation of pedestrian walk and clearance interval. The start-up sequence shall end with the major street left turn green interval (movements 1 and 5), at which time the controller unit shall operate as an actuated controller.

A671-1.14 Recall and Detector Memory

The following functions shall be furnished for each phase of the controller unit. The controls for each function shall be located on the front face panel of the controller unit.

Vehicle Recall:
Off: Phase is not recalled.

Minimum recall: The controller unit automatically returns to the phase programmed for minimum recall and provides vehicle right-of-way for at least the minimum green time without need of vehicle demand. However, if the programmed phase has the right-of-way and a conflicting call is present, then the controller unit shall operate as an actuated controller. The pedestrian walk and clearance interval are not served unless a call is present.

Maximum recall: The controller unit automatically returns to the phase programmed for maximum recall and provides the vehicle right-of-way for the time set on the maximum interval timing control without the need of vehicle demand. Termination of the green interval shall not expire unless there is a demand on a conflicting phase. The pedestrian walk and clearance interval are not served unless a call is present.

Pedestrian Recall:
Off: Phase is not recalled.

Ped recall: The controller unit automatically returns to the phase programmed for ped recall and provides vehicle and pedestrian right-of-way in the same manner as an external pedestrian call, except that it shall not recycle the pedestrian service until an opposing phase is serviced.

Detection Memory:
Lock: Memory of vehicle actuation is locked into the controller unit until that phase is serviced.

Non-lock: Memory of vehicle actuation is retained in the controller unit for the length of time that the vehicle detector input signal for that phase is held at a logic low.

A671-1.15 Indicator Lights

Indicator lights or indications on a backlit LCD shall be provided within the controller assembly and appropriately labeled to facilitate the determination of the operation of the controller unit. These indications shall consist of the following as a minimum requirement:

- Phase or phases in service
- Phase or phases next to be serviced
- Presence of vehicle call, including memory and detector actuations
- Presence of pedestrian call

The following interval information shall be displayed for the phase in service on a per ring basis:

- Minimum green
- Passage time
- Yellow clearance
- Red clearance
- Walk
- Pedestrian clearance
- Reason for termination (gap-out, maximum timed out, force-off)
- Rest state (dwell)

A671-1.16 Timing Accuracy of Intervals:

Settability: The settability shall be fixed discrete increments.

Repeatability: The digital timing shall relate to the input line frequency such that no cumulative or drift errors will occur in timing intervals. No interval shall deviate by more than plus or minus 100 ms from its set value at a power source frequency of 60 Hz.

Interval Timing:
The following intervals, with the associated timing ranges and maximum increments, shall be provided for each phase of the controller unit:

Interval	Minimum Range (Seconds)	Maximum Increment (Seconds)
Minimum Green	1-30	1
Passage Time	*0-9	0.1
Maximum Green I & II	1-99	1
• Yellow Clearance	3-7	0.1
Red Clearance	*0-7	0.1
Walk	1-30	1
Pedestrian Clearance	*0-30	1

*Zero shall be satisfied by any time between 0 and 100 ms.

- Yellow clearance shall not be less than three seconds.

When volume density features are specified in the contract documents, the following intervals with the associated timing ranges and maximum increments shall be provided for each phase of the controller unit:

Interval	Minimum Range (Seconds)	Maximum Increment (Seconds)
Added Initial	*0-3 per actuation	0.1
Time to reduce	1-60	1
Time before reduction	1-60	1
Minimum gap	0-7.75	0.1

*Zero shall be satisfied by any time between zero and 100 ms.

A671-1.17 Overlaps

Types D4-4 and D8 controller units shall be furnished with four internally generated overlaps, designated alphabetically A, B, C, and D.

The timing for the yellow and red clearance overlap signals shall be determined by either:

- The phase terminating the overlap, or
- An independent adjustment for each overlap signal.

The method of programming of overlap signal controls may be by use of an interchangeable plug-in printed circuit board assembly or by means optional to the manufacturer. Details of the printed circuit board assembly may be obtained from the State Traffic Engineering and Operations Office. If the manufacturer chooses to not use a printed circuit board assembly for programming overlaps, the manufacturer shall supply a programmed, printed circuit board assembly with each controller.

Each overlap (A, B, C, D) shall be programmable with respect to phase assignment on a per ring basis.

For lead left turn, phase 1 is used for major street left turn; Phase 2 for major street through; Phase 3 for minor street left turn; Phase 4 for minor street, through. For lag left turn, Phase 1 is used for minor street left turn; Phase 2 for major street through; Phase 3 for major street left turn; Phase 4 for minor street through.

For lead left turn, Phases 1 and 5 are used for major street left turns; Phases 2 and 6 for major street through movements; Phases 3 and 7 for minor street left turns; Phases 4 and 8 for minor street through movements.

A671-1.18 Preemption Operation

The logic for controlling railroad, bridge and fire preemption signal sequences and timing shall be contained internally in the controller unit.

The order of priority of preemption calls shall be as follows:

1) Railroad
2) Bridge
3) Fire
4) Transit

When the controller unit is in the non-preemption green movement and the preemption circuit is activated, a minimum green time from three to 30 seconds (adjustable in one second increments) shall be timed by the preemption logic. If a pedestrian walk interval is timed upon activation of the preemption circuit, the preemption logic shall immediately advance the controller unit to the pedestrian clearance interval. The setting of the minimum green time shall be the pedestrian clearance interval time. The timing ranges for all other preemption intervals shall be as shown in the plans.

An additional connector shall be furnished for the preemption interconnect signal. This additional connector can be Connector D as specified in 671-1.24 and shall not interface with the controller's standard I/O connector(s).

Priority of Input Functions:
The priority of input functions shall be in the following order:

1) Power-up
2) External start
3) Phase omit
4) Pedestrian omit
5) Interval advance
6) Stop timing
7) Manual control enable
8) Force-off
9) Hold

Each function listed above shall take precedence over and completely negate functions below it while activated.

A671-1.19 Coordination

Traffic signal system coordination whose function is to control the timed relationship between intersections so as to maintain a system interconnect plan, is covered below. Coordination functions to control intersection cycle lengths, system offsets, and phase splits shall be provided as a standard feature, with no need for additional modules or software.

A671-1.20 Classification of Coordination Unit

Type Designation: A "secondary" coordination mode shall be used to maintain the selected offset timing between the master intersection and the secondary intersections by imposing a background cycle on the secondary intersection controller unit.

A "master" coordinator mode (Type DMI) shall be used to generate a synchronization pulse once per cycle to maintain the selected offset timing between the master intersection and the secondary intersections. The master coordinator shall also impose a background cycle on the master intersection controller unit in order to maintain the system offset timing from the master location.

“Time-based” coordination mode (Type TBCI) shall be use as an internal time-of-day (TOD) clock referenced to a user’s selected reference time (sync reference), to maintain the selected cycle length, system offset, and phase split timings of an intersection controller unit. When the time-based coordinator is in the FREE MODE, the controller unit shall operate as an actuated controller.

A671-1.21 Design Requirements

Background Cycle: All coordination modes shall be provided with three independently programmable background cycles. The background cycles shall be settable in fixed increments not to exceed five seconds. The repeatability of the cycle time shall not deviate by more than ±100 ms of the set value.

Offsets: Offset is defined as the time relationship expressed in seconds or percent of cycle length, determined by the difference between a defined interval point of the coordinated phase green and a system reference point.

The coordinator shall be provided with three programmable offsets per cycle. The range of programmability shall be from 1 to 99 percent of the cycle length in maximum increments of 1 percent or 0 to 255 seconds in 1 second increments.

Type DMI coordinator shall generate a synchronization pulse once per cycle for establishing and maintaining the interconnected system offset relationship.

Offset transition for Type DSI coordinator shall be distributed over 2 to 3 cycle lengths.

TBC mode shall be provided with at least three independently programmable background cycles. The background cycle shall be settable in fixed increments, not exceed five seconds. The repeatability of the cycle time shall not deviate by more than ±100 ms from the programmed value.

The offset transition technique of the TBC mode shall not cause the controller unit to extend the green interval of any phase by more than 20 percent of the background cycle in effect. At the completion of the offset time, the TBC mode shall time the yield period.

A671-1.22 Cycle Split Sets

A cycle split set is defined as a percentage of the cycle length allocated to the various phases of the controller unit.

Each cycle split set provided with the coordinator shall have three independently programmable force-off points, designated force-off (F.O.) 1, F.O.2, and F.O.3 for allocating a division of time within a cycle length for each of the non-coordinated phases of the controller unit.

Force-Off: The coordinator shall provide a force-off mode which is used to activate the internal force-offs of the controller unit. The force-off point of the coordinator shall be assignable to any or both rings 1 and 2 force-off mode of a dual ring controller setup.

The force-off points shall be programmable in maximum increments of 1 percent of the cycle length between the 0 and 99 percent points of the cycle or 0 to 255 seconds in 1 second increments.

Each force-off point of a cycle split set shall be assigned to control a particular phase of the controller unit. F.O.1 shall control the phase(s) immediately following the coordinated phase(s). F.O.2 shall control the phase(s) immediately following the phase(s) controlled by F.O.1. F.O.3 shall control the phase(s) immediately following the phase controlled by F.O.2. The phase controlled by F.O.3 shall be the phase(s) which is prior to the coordinated phase(s).

Force-off points shall activate the force-off output of the coordinator if the phase controlled by the force-off point is green. The force-off output shall remain active until the phase(s) is forced off.

Yield Period: The yield period shall be the time in the background cycle where the coordinated phase is terminated, subject to the presence of a conflicting call. The coordinator shall continually apply a hold signal to the controller unit coordinated phase(s) except during the yield and permissive periods.

The end of the hold mode during the yield and permissive periods from the coordinator shall be of sufficient time to allow the controller unit to terminate the coordinated phase(s), subject to presence of conflicting calls.

Permissive Periods: Permissive periods are programmable intervals in the cycle in which the coordinator releases the hold input to the coordinated phase(s) of the controller unit, allowing the controller unit to service calls on the actuated phases as described below.

Permissive Period Number 1 (PP1) shall allow the controller unit to yield to a call on the phase(s) immediately following the coordinated phase(s).

PP1 shall start timing at the zero percent point of the cycle and shall be fully programmable to stop timing from 0 to 99 percent of the cycle in maximum increments of 1 percent.

Permissive Period Number 2 (PP2) shall allow the controller unit to yield to calls on actuated phases as follows:

- If the controller unit yielded to a call during PP1, then PP2 shall be inhibited from timing. The controller unit shall be allowed to service the remaining phases in normal sequence, subject to the requirement of these specifications.
- If the controller unit did not yield to a call during PP1, then PP2 shall be allowed to time. During PP2 the controller unit shall be allowed to service calls on all phases except for

the phase(s) immediately following the coordinated phase. The start and end points for timing PP2 shall be fully programmable from 0 to 99 percent of the cycle length, in maximum increments of 1 percent.

Non-Early Release: The coordinator shall not allow the controller unit to advance out of any actuated (non-coordinated) phase until the force-off point value for that phase has completed timing.

The coordinator shall be programmed so that any actuated phase can be converted to early release operation, i.e., actuated phase can terminate prior to the completion of the programmed force-off point time.

Outputs and Inputs: All outputs and inputs of the coordination connector which directly interface with the controller cabinet must conform to the INPUT-OUTPUT requirements of Section A671-1.34.

Timing Requirements: The timing controls for programming the cycle length, offsets, force-off points and permissive periods shall be as approved by the FDOT. All timing controls shall be color or function coded.

All function timing shall be digital and use the 60 Hz power as the reference. The timing accuracy of any interval shall not deviate by more than ±100 ms from its set value at a power source frequency of 60 Hz.

The timing ranges and maximum increments of adjustment for the various timing functions of coordination shall be as indicated in the chart below:

Minimum Function	Timing Range	Maximum Increment of Adjustment
Cycle Length	40 to 255 seconds	1 second
Offsets	0 to 150 seconds	1 second
Force-off points	or	or
Permissive Periods	1 to 99 percent of cycle length or 0 to 255 seconds	1 percent of cycle length 1 second

A671-1.23 Indicator Requirement

TBC coordinator shall provide the following minimum indications:

- Time of day (hours/minutes/seconds, in military time)

- Day of week
- Ten outputs controlled by day program
- Cycle Zero - indicates beginning of background cycle
- Day program in effect
- Week program in effect
- Battery status

A671-1.24 Input-Output Connectors D

Electrical connections to and from all coordination modes to the controller cabinet circuitry shall be made with a connector approved by the FDOT and labeled Connector D.

The cable harness connector for Connector D shall not mate with any of the controller assembly connectors as specified in Section A671-1.35.

A cable harness connector and wire harness, at least five feet (1.5 m) in length shall be furnished.

A671-1.25 Clock Circuit for TBC

The clock circuit of the TBC may use either the 60 Hz AC power source or a crystal oscillator as the timing reference. If a crystal oscillator is used as the timing reference, the frequency tolerance of the clock circuit shall be ±0.0015 percent. The clock circuit of the TBC unit shall be settable to the nearest second.

The TBC shall be provided with a programmable feature which automatically changes from standard time to daylight savings time and vice versa.

A671-1.25.1 Battery Power

The TBC shall be provided with a battery to power the clock circuit and memory for a minimum of 6 months when the 120 V AC power source is disconnected, after batteries are fully charged.

The frequency tolerance of the clock circuit, when operated on battery power shall be ± 0.0015 percent. Repetitive transfer from battery power to 120 V AC power to battery power, and voltage brown-outs (voltage less than 96 V AC) shall not affect the accuracy of the TBC clock circuit.

A671-1.25.2 Day Programs

The TBC shall be provided with a minimum of 10 day programs. A day program is used to specify which output circuit will turn on or off during a 24-hour period (i.e., dial 1, offset 1, split 1, etc.). The 10 day programs shall be provided with a minimum total of 120 changes (ons or offs).

A671-1.25.3 Exception Days

The TBC shall be provided with a minimum of ten exception days. An exception day is used for a certain day of the year instead of the normal day program (i.e., holiday, special event, etc.). The 10 exception days program shall be provided with a minimum total of 120 changes (ons or offs).

A671-1.25.4 Week and Year Programs

The TBC shall be provided with a minimum of ten "week" programs. A week program is used to specify which day program will be used for each day of the week.

The TBC shall be provided with one "year" program. This year program is used to specify which week program will be used for each week of the year.

A671-1.25.5 Manual Override

The TBC shall be designed so that the programmed time of day function can be manually overridden to select a different function, i.e., dial, offset, split, etc.

A671-1.25.6 Printer

The TBC unit shall be designed to output all programmed parameters to an external PC computer or printer.

A671-1.25.7 Program Transfer

The TBC unit shall have capability of loading program information from one TBC to another TBC of the same manufacturer, or other approved methods.

A671-1.25.8 Easy Program Erase Feature

The TBC unit shall be provided with an easy program erase feature to completely erase all programs.

A671-1.25.9 Transition Period

In any TBC system the transition from cycle length, split change, offset change, etc., to another shall occur within a maximum of ±1 second of the designated transition time programmed into the TBC for that system.

A671-1.26 Printed Circuit Boards

All printed circuit boards shall be made from NEMA (FR-4) glass-epoxy, or equivalent (*See* current edition NEMA Standards Publication No. LI 1., Industrial Laminated Thermosetting Products). Circuit boards exceeding 2 inches (51 mm) in any dimension shall have a nominal thickness of at least 1/16 inch (1.58 mm). Circuit boards not exceeding 2 inches (51 mm) in any dimension shall have a nominal thickness of at least 1/32 inch (0.79 mm). The walls of all plated through holes shall have a minimum copper plating thickness of .001 inch (25 µm). All circuit tracks shall have a conductivity equivalent to at least two ounces per square foot (610 g/m2) of copper. All electrical mating surfaces shall be made of non-corrosive material.

A671-1.27 Component Identification

The controller unit shall be so designed that each component is identified as a circuit reference symbol. The identification shall be affixed to the printed circuit board(s), the unit cover, or in an assembly drawing provided with the unit.

A671-1.28 Power Supply

The power supply shall be easily removable from the main-frame with the use of only common tools. The power supply shall have over-voltage and over-current protection for all DC minus voltages.

A671-1.29 Frame Dimensions

The controller unit shall be designed to mount on a shelf. The height of the controller unit shall not exceed 15 inches (381 mm). The depth of the unit, including connectors, harnesses and protrusions, shall not exceed 14.5 inches (368 mm).

A671-1.30 Frame Requirements

The controller frame shall be sturdy construction and shall be equipped with card guides and edge card connectors to receive the various plug-in modules. A minimum of two card guides per module slot shall be furnished with the frame. The modules shall be interconnected by means of a motherboard assembly or other approved method.

The power supply and input output connectors shall be considered as part of the controller frame. The controller frame shall also include all modules that are required to make the controller assembly operate as per these specifications.

A671-1.31 Housing Requirements

The controller frame shall be furnished completely enclosed in a durable sheet aluminum or approved alternate housing, with a durable finish. The housing shall be designed to adequately dissipate the heat generated by the controller circuitry. The controller frame shall have the serial number permanently stamped, engraved or printed on the front of the housing.

A671-1.32 Modular Requirements

Each module shall have the model number or nomenclature of the manufacturer and the serial number permanently stamped, engraved or printed on it.

A671-1.33 Logic and Current Levels

All logic signals shall be low state (nominal 0 V) for the TRUE (operate) state of all input and output terminations. Input-output terminations, when not activated, shall be internally biased to the FALSE state (+24 V DC).

A671-1.34 Input and Output Characteristics

Input Characteristics:

- A voltage between 0 and 8 V shall be considered the "low" state.
- A voltage greater than 16 V shall be considered the "high" state.
- The transition from "low" state to "high" state (and vice-versa) shall occur between eight and 16V.
- External transition from "low" to "high" state (and vice-versa) shall be accomplished within 0. 1 mA.
- Over the voltage range 0 to 24 V DC (± 2 V), the maximum current "in" or "out" of any input control terminal shall be less than 10 mA. Input impedance shall not exceed 11k S to 24 V DC, nor shall the surge impedance be less than 100 S resistive.
- Any input signal dwelling in a defined logic state for less than 0.25 ms shall not be recognized. Any input signal dwelling in a defined logic state for more than 30 ms shall be recognized. Successive similar logic state transitions shall not be recognized when occurring less than 10 ms apart, and shall be recognized when occurring more than 135 ms apart.

Output Characteristics:

- The "low" (operate) voltage shall be between zero and 4 V.
- Current sinking capability in the "low" state (true) shall be at least 200 mA from an inductive load.
- With an external impedance of 100 kS or greater the transition from 4 to 16 V (and vice-versa) shall be accomplished within 0.1 ms.
- "High" state impedance shall not exceed 11 kS to 24 V DC.
- Any external steady state voltage applied to an output terminal shall not exceed + 30 V DC, nor shall it cause flow of more than 3 mA into the terminal when the output is in the high state.
- Any valid TRUE output signal shall dwell in this state for at least 50 mA

A671-1.35 Connectors

The connectors on the controller unit shall have a metallic shell which is connected to the internal chassis ground. The connectors shall be mounted on the front of the controller unit. Cable harnesses shall be at least 6 feet (1.8 m) in length.

Electrical connections to and from the controller unit shall be made by the use of MIL-C-26482 series connectors except for Connector D.

- Connector A shall intermate with an MS-3116()- 22-55S.
- Connector B shall intermate with an MS-3116()- 22-55P.
- Connector C shall intermate with an MS-3116()- 24-61P.
- Connector D shall not intermate with any of the above connectors.

The connectors, as specified above, shall be provided with the controller type as specified below:

Type Controller	Required Connectors
D4-4, D8	A, B, C and D

A671-1.36 Pin Terminals

Inputs – Types D4-4 and D8 controller units shall have the following number of input terminals:

Function	No. of Terminals per Unit D4-4, D8
Vehicle Detector (Per Phase)	8
Pedestrian Detector Calls (Per Phase)	8
AC+ (Line Side)	1
AC - (Common)	1
Chassis Ground	1
Logic Ground	1
Force Off (Per Ring)	2
Hold (Per Phase)	8
Phase Omit (Per Phase)	8
Stop Timing (Per Ring)	2
Interval Advance (Per Unit)	1
Manual Control Enable (Per Unit)	1
Red Rest (Per Ring)	2
Inhibit Max Termination (Per Ring)	2
Call to Non-Actuated Mode (2 per Unit)	2
External Min. Recall to All Vehicle Phases (Per Unit)	1
Omit Red Clearance (Per Ring)	2
Maximum II Selection (Per Ring)	2
Indicator Lamp Control (Per Unit)	1
Pedestrian Omit (Per Phase)	8
Test Input (2 Per Unit)	2
External Start (Per Unit)	1
Pedestrian Recycle (Per Ring)	2

Walk Rest Modifier (Per Unit)	1
Total No. of Inputs	68

Outputs – Types D4-4 and D8 controller units shall have the following number of output terminals:

Function	No. of Terminals per Unit D4-4, D8
Load Switch Drivers Basic Vehicle (G-Y-R, Per Phase)	24
Load Switch Drivers Pedestrian (W-PC-DW, Per Phase)	24
Load Switch Drivers Overlap (G-Y-R, Overlaps Maximum)	12
Check (Per Phase)	8
Phase on Logic (Per Phase)	8
Phase Next Logic (Per Phase)	8
Coded Status Bits (3 Per Ring)	6
Controller Unit Voltage Monitor (Per unit)	1
Regulated 24 Volt DC for External Use	1
Flashing Logic Output	1
Total No. of Inputs	93

A671-1.37 Pin Assignments

Connector A (-22-55P) for Types D4-4 and D8 controller units shall conform to the following connector pin termination tabulation.

Pin	Function	Pin	Function
A	Reserved	f	Φ1 Vehicle Call Det
B	+24 V DC External	g	Φ1 Ped Call Det
C	Voltage Monitor	h	Φ1 Hold
D	Φ1 Red Driver	i	Force-Off
E	Φ1 Don't Walk Driver	j	Exit Min Recall All 0's
F	Φ2 Red Driver	k	Manual Control Enable
G	Φ2 Don't Walk Driver	m	Call to Non Act I
H	Φ2 Ped Clear Driver	n	Test Input A
J	Φ2 Walk Driver	p	AC + (Control)
K	Φ2 Vehicle Call Det	q	Spare 1
L	Φ2 Ped Call Det	*r	Coded Status Bit B (1)
M	Φ2 Hold	s	Φ1 Green Driver
*N	Stop Timing (1)	t	Φ1 Walk Driver
*P	Inhibit Max Term (1)	u	Φ1 Check
R	External Start	v	Φ2 Ped Omit
S	Interval Advance	*w	Omit All Red Clear (1)
**T	Indicator Lamp Control	*x	Red Rest Mode (1)
U	AC - (Common)	y	Spare 2
V	Chassis Ground	z	Call To Non Act II

W	Logic Ground	AA	Test Input B
X	Flashing Logic Out	BB	Walk Rest Modifier
*Y	Coded Status Bit C (1)	*CC	Coded Status Bit A (1)
Z	Φ1 Yellow Driver	DD	Φ1 Phase On
a	Φ1 Ped Clear Driver	EE	Φ1 Omit
b	Φ2 Yellow Driver	*FF	Ped Recycle (1)
c	Φ2 Green Driver	*GG	Max II Selection (1)
d	Φ2 Check	HH	Spare 3
e	Φ2 Phase On		

*Number in parenthesis refers to ring number.
**Pin "T" is required when incandescent lamps are used.

Connector B (-22-55S) for Types D4-4 and D8 controller units shall conform with the following connector pin termination tabulation:

Pin	Function	Pin	Function
A	Φ1 Phase Next	f	Φ4 Phase Next
B	Spare 1	g	Φ4 Phase Omit
C	Φ2 Phase Next	h	Φ4 Hold
D	Φ3 Green Driver	i	Φ3 Hold
E	Φ3 Yellow Driver	j	Φ3 Ped Omit
F	Φ3 Red Driver	k	Φ6 Ped Omit
G	Φ4 Red Driver	m	Φ7 Ped Omit
H	Φ4 Ped Clear Driver	n	Φ8 Ped Omit
J	Φ4 Don't Walk Driver	p	OL A Yellow Driver
K	Φ4 Check	q	OL A Red Driver
L	Φ4 Vehicle Call Det	r	Φ3 Check
M	Φ4 Ped Call Det	s	Φ3 Phase On
N	Φ3 Vehicle Call Det	t	Φ3 Phase Next
P	Φ3 Ped Call Det	u	OL D Red Driver
R	Φ3 Phase Omit	v	Spare 4
S	Φ2 Phase Omit	w	OL D Green Driver
T	Φ5 Ped Omit	x	Φ4 Ped Omit
U	Φ1 Phase Omit	y	Spare 5
*V	Ped Recycle (2)	*z	Max II Selection (2)
W	Spare 2	AA	OL A Green Driver
X	Spare 3	BB	OL B Yellow Driver
Y	Φ3 Walk Driver	CC	OL B Red Driver
Z	Φ3 Ped Clear Driver	DD	OL C Red Driver
a	Φ3 Don't Walk Driver	EE	OL D Yellow Driver
b	Φ4 Green Driver	FF	OL C Green Driver
c	Φ4 Yellow Driver	GG	OL B Green Driver
d	Φ4 Walk Driver	HH	OL C Yellow Driver
e	Φ4 Phase On		

*Numbers in parenthesis refers to ring numbers.

Connector C (-24-61S) for Types D4-4 and D8 controller units shall conform to the following connector pin termination tabulation:

Pin	Function	Pin	Function
A	Coded Status Bit A (2)	I	Φ5 Green Driver
B	Coded Status Bit B (2)	j	Φ5 Walk Driver
C	Φ8 Don't Walk Driver	k	Φ5 Check
D	Φ8 Red Driver	m	Φ5 Hold
E	Φ7 Yellow Driver	n	Φ5 Phase Omit
F	Φ7 Red Driver	p	Φ6 Hold
G	Φ6 Red Driver	q	Φ6 Phase Omit
H	Φ5 Red Driver	r	Φ7 Phase Omit
J	Φ5 Yellow Driver	s	Φ8 Phase Omit
K	Φ5 Ped Clear Driver	t	Φ8 Vehicle Call Det
L	Φ5 Don't Walk Driver	*u	Red Rest Mode (2)
M	Φ5 Phase Next	*v	Omit All Red (2)
N	Φ5 Phase On	w	Φ8 Ped Clear Driver
P	Φ5 Vehicle Call Det	x	Φ8 Green Driver
R	Φ5 Ped Det	y	Φ7 Don't Walk Driver
S	Φ6 Vehicle Call Det	z	Φ6 Don't Walk Driver
T	Φ6 Ped Call Det	AA	Φ6 Ped Clear Driver
U	Φ7 Ped Call Det	BB	Φ6 Check
V	Φ7 Vehicle Call Det	CC	Φ6 Phase On
W	Φ8 Ped Call Det	DD	Φ6 Phase Next
X	Φ8 Hold	EE	Φ7 Hold
*Y	Force Off (2)	FF	Φ8 Check
*Z	Stop Timing (2)	GG	Φ8 Phase On
*a	Inhibit Max Term (2)	HH	Φ8 Phase Next
b	Spare 1	JJ	Φ7 Walk Driver
*c	Coded Status Bit C (2)	KK	Φ7 Ped Clear Driver
d	Φ8 Walk Driver	LL	Φ6 Walk Driver
e	Φ8 Yellow Driver	MM	Φ7 Check
f	Φ7 Green Driver	NN	Φ7 Phase On
g	Φ6 Green Driver	PP	Φ7 Phase Next
h	Φ6 Yellow Driver		

*Numbers in parenthesis refer to ring number.

A671-2 Model 170E Traffic Controller

This section specifies the minimum requirements for the certification of the Model 170E Microcomputer Traffic Signal Controller. The Model 170E controller, through the use of various software programs shall be programmed to operate as a full actuated, semi-actuated or pre-timed controller and shall have urban traffic control system and closed-loop traffic control system interface capability.

The controller shall be a microprocessor-based microcomputer. The Model 170E controller shall be battery-free (except for the 412C Program Module) with all random access memory (RAM) of the non-volatile type (NOVRAM) and a super capacitor used to provide standby power to the system down time accumulator (DTA) in place of standard batteries.

For the entry of timing data and operational parameters, it shall incorporate a keyboard in the front panel and have the capability to accept an external field transportable unit (FTU) for entry of this data. Manufacturers seeking approval for their device shall provide the FDOT with a unit to be evaluated by the State Traffic Engineer in accordance with these specifications.

Documentation indicating the furnished unit meets all specified requirements shall be provided before any evaluation is to take place.

A671-2.1 General Requirements

The hysteresis between power failure and power restoration voltage setting shall be a minimum of 5 V with a threshold drift of no more than 0.2 V AC.

A671-2.2 Power Failure

A power failure is said to have occurred when the incoming line voltage falls below 92 (±2) V AC for 50 ms. The determination of the 50 ms interval shall be completed with 67 ms of the time the voltage first reaches 97 (±2) V AC.

A671-2.3 Memory Access Time

The total memory access time, including buffering, decoding, device access time, and accessed data presented to the controller unit data bus, shall not exceed 300 ms. The memory device shall have read and write (if applicable) time suitable to perform either function in one micro processor unit (MPU) instruction cycle.

A671-2.4 Memory Device

Each memory device shall stabilize to normal operation within 10 ms following power restoration and shall be in standby until addressed. Each device shall have the following maximum power drain at +5 V DC in its various states as listed in Figure A671-1.1.

FIGURE A671-1.1

MEMORY	ACTIVE	STANDBY	POWER DRAIN
EPROM	100 mA	40 ma	--
SCRAM	70 mA	20 mA	100 µA (non-inverting power)

A671-2.5 Memory Sockets

All memory sockets shall be a 28 Pin AUGUT #528/828 Series-AG10DPC or approved equivalent, except CPU SRAM which shall be a 24 Pin or approved equivalent. Each socket number shall be permanently marked on the printed circuit board (PCB) adjacent to its Pin #1.

A671-2.6 System Address Organization

The general system address organization of the Model 170E shall be as listed in Figure A671-1.2. The internal module address organization shall be as specified in the appropriate module section.

FIGURE A671-1.2

MODEL 170E CONTROLLER UNIT

GENERAL SYSTEM ADDRESS ORGANIZATION

FUNCTION	ADDRESS RANGE	COMMENTS
CPU SRAM	0000-07FF	
RESERVED	0800-0FFF	
U4 MEMORY	1000-4FFF	
DTA MINUTES	5000-READ	5000 WRITE REST DTA
INOUT/OUTPUT	5001-500A	5001 BIT 1 INPUT ASSIGNED TO RESET TIMER 5009 & 500A READ RESERVED
RESERVED	500B-500E	
DTA SECONDS	500=READ	500F WRITE RESERVED
RESERVED	1010-5FFE	

REAL TIME CLOCK RESET	5FFF-WRITE	5FFF READ RESERVED
ACIA	6000	WRITE CR, READ SR
ACIA	6001	WRITE TDR, READ RDR
RESERVED	6001-6FFF	
PROGRAM MODULE		
MEMORY WRITE PROTECT	7000-WRITE	
ID FEATURE	7000-READ	
ID LOCATION	7001-READ	
MPU/MIC INTERFACE	7002	
RESERVED	7003-7009	
RTCA VALID/RESET	700A	
RTCA COUNTERS 1 TO 4	700B-700E READ	700B-700E WRITE RESERVED
U3 MEMORY	7010-7FFF	FUNCTION 700F RESERVED
U1 & U2 MEMORY	8000-FFF	

A671-2.7 Device Coding

If a PAL, EPROM or ROM device is used in address decoding and timing algorithms, the device code listing together with data sheet(s) and any specific coding requirements shall be included in the unit or module documentation. The device coding shall be delivered in the same form that the manufacturer/vendor uses to directly reproduce the device.

A671-2.8 Diagnostic and Acceptance Test Program

The diagnostic and acceptance test (DAT) program shall be provided on the program module for the testing of the Model 170E controller unit and associated modules.

A671-2.9 Unit Composition

The Model 170E controller unit shall consist of the following:

- Input/Output Interface
- Unit Chassis
- Unit Power Supply with External Power Connection
- Unit Standby Power Supply
- Front Panel Assembly
- Internal System Interface
- Connectors C1S, C2S, and T-1
- Communications System Interface
- Model 412 Program Module

The composition weight shall not exceed 25 pounds.

A671-2.9.1 Central Processing Unit

The central processing unit (CPU) shall be provided with an MPU and shall properly execute object programs developed to operate on the MPU. The MPU interrupt requirements shall be as follows:

A671-2.9.2 Non-Maskable Interrupt

The non-maskable interrupt (NMI) is exclusively assigned to the power failure function. A power failure shall cause the MPU NMI line to immediately go LOW. The line shall be held LOW until the RES goes LOW to prevent multiple NMI issuances.

A671-2.9.3 Reset Interrupt

The reset interrupt (RES) is exclusively assigned to power restoration and MPU start-up. The RES line shall go LOW 3 (±1) ms following the NMI going LOW. The line shall remain LOW unit ±75 ms after power restoration.

A671-2.9.4 Interrupt Request

The interrupt request (IRQ) line shall be jointly used by the real-time clock (RTC) and asynchronous communications interface adapter (ACIA) to initiate IRQ to the MPU.

a) RTC - RTC circuitry shall be provided to trigger an interrupt to the MPU on the IRQ line once every 1/60 of a second during the 0° to 15° portion of the negative portion of the AC Sine Wave. The AC Sine Wave shall be derived from the local power company's 120 V AC 60 Hz frequency. The RTC shall be reset by a write to Address 5FFF.

b) ACIA -- Four ACIA shall be provided capable of receiving and transmitting up to eight-bits of parallel data from the MPU for serial data communications. The ACIAs shall have four registers which are addressable by the MPU. The MPU shall be capable of reading the status register (SR) and the receiver data register (RDR), and writing in the transmit data register (TDR) and in the control register (CR).

A671-2.9.5 CPU Clock Timing:

The CPU clock circuitry shall be provided to generate the MPU clock timing. The clock circuitry and the MPU shall provide a MPU machine cycle time of 1.302 (±0.0015) microseconds. The CPU clock circuitry shall be located no further than 50 mm (2-inches) from the MPU clock pin inputs.

A671-2.9.6 Downtime Accumulator

a) A downtime accumulator (DTA) shall be provided to accumulate time between power failure and restoration. The DTA shall start counting immediately upon power failure and continue counting until the RES line goes HIGH following power restoration.
b) The DTA shall have two 8-bit registers counting the number of minutes and seconds. DTA accuracy shall stop counting when the minutes register equals 255 decimals. Both DTA registers shall reset to zero by a WRITE to Address 5000. The DTA shall READ Minutes at Address 5000 and Seconds at Address 500F. The Seconds Register shall count (0) to fifty-nine (59) seconds decimal in second increments. At (60) seconds decimal, The Minutes Register shall be incremented and the Seconds Register reset to zero.

A671-2.9.7 Static Random Access Memory:

Static random access memory (SRAM) of 2,048 eight-bit words shall be provided.

A671-2.9.8 Restart Timer:

Restart timer circuitry shall be provided to react to the duration of power outage. The restart timer output is normally HIGH. When the NMI lines goes LOW, the restart time shall begin timing. If the timer reaches 1.75 (±0.25) seconds, its output state shall go to LOW and remain in that state for 50 (±24) milliseconds after the RES line goes HIGH. If power is restored prior to the timer timing out, the output shall remain HIGH and the timer shall be reset to zero.

A671-2.9.9 Current Drain DTA and Restart Timer Circuitry:

Total current drain for DTA and restart timer circuitry and SRAM (power-down mode) shall not exceed 2 milliamperes at 4 V DC, 35 °C (95 °F).

A671-2.10 Input/Output Interface:

Input/output interface shall utilize a ground true logic. The transfer of data between interface and working registers within the MPU shall be in eight-bit increments, minimum. The steering of data from inputs or outputs for a given address shall be controlled by the state of MPU read/write command at the time the given address is valid.

A671-2.10.1 Input Interface:

The input interface shall consist of a minimum of 64 bits of gated inputs from external devices. Each logic level input shall be turned ON (true) when the input voltage is less than 3.5 V DC; shall be turned OFF (false) when the input current is less than 100 microamperes or the input voltage exceeds 8.5 V DC; shall pull up to 12 V DC; shall not deliver in excess of 20 milliamperes to a short circuit to logic level common. When the appropriate input address is impressed upon the input interface, the interface shall place its data on the data bus, which will be read by the MPU. Ground on any input shall be interpreted by the MPU as a "1" and an open on any input or the presence of a voltage greater than 8.5 V DC shall be integrated as a "0" by the MPU when that input is read.

A671-2.10.2 Output Interface:

The output interface shall consist of minimum of 80 bits of buffered storage. Output data shall be latched at the time of writing from the MPU. This interface shall provide an NPN open collector output capable of driving up to 40 V DC and sinking up to 100 milliamperes. A "1" from the MPU shall be present as a ground collector, and a "0" presented as an open circuit. Once a port is written into the data, it shall remain present and stable until either another word is written into it or until the power is turned off. The state of these output ports at the time of power up or below power failure threshold shall be an open circuit.

A671-2.11 Unit Chassis:

Controller unit shall be housed in a compact, portable, metal enclosure suitably protected against corrosion. The controller unit shall be designed to mount in a standard Electronic Industries Association (EIA) 19-inch (483 mm) rack. The enclosure shall be designed for convenient removal of PCBs without the use of tools. Figure A671-3.1 provides a general illustration of the dimensions and layout of the Model 170E controller unit chassis/cabinet. When the controller unit is equipped with a fan, thermal overload protection for the fan shall be provided.

The controller unit SHALL have only VERTICALLY MOUNTED CIRCUIT BOARDS due to potential heat build-up problems. Any controller unit that uses horizontally mounted circuit boards will not be considered usable in this specification.

A671-2.12 Unit Power Supply:

Power supply shall be provided to produce all DC power necessary to operate the controller unit. In addition, the supply shall provide the following voltages and current:

1000 mA at +12 V DC
300 mA at -12 V DC
500 mA at +5 V DC
400 mA at -5 V DC

a) The DC ground shall not be connected to the equipment ground.
b) Controller unit power shall be held up (DC logic levels at normal operating levels) for a minimum of 50 (±17) ms beyond the NMI line going LOW.
c) The maximum DC voltage generated shall not exceed 45 V.
d) The power supply shall be so designed that no further filtering regulation is needed for the required DC voltages.
e) If a switching power supply is used, radio frequency suppressor shall be proved on the AC+ and AC- power lines.

A671-2.13 Unit Standby Power Supply:

A standby power supply shall be provided to retain power to the CPU restart timer, DTA, and SRAM during power failure in the controller unit. All SRAM shall be of the non-volatile type (NOVRAM) and a super capacitor shall be used to provide standby power to the system. DTA shall be used in place of standard batteries; batteries shall not be acceptable.

A671-2.14 Front Panel Assembly:

All Model 170E controller units shall be provided with the minimum requirements specified in this subsection.

a) The front panel shall be securely fastened to the chassis and removable without the need for tools. A continuous hinge shall be provided on the left side of the unit to permit opening of the front panel and ready access to the interior of the controller unit.
b) The front panel shall be electrically connected by means of Connector C3. The front panel shall be connected to equipment ground through Connector C3.
c) The front panel shall be provided with ten LED CALL/ACTIVE indicators.
d) The character displays shall be hexadecimal with circuits to accept, store, and display four-bit binary data. The characters shall be 0.40 inches (10 mm) high, minimum. Each character shall have latch strobe and blanking inputs. The second character from the right lower shall have a right decimal point. The face of the character display shall be scratch and solvent-resistant. The transfer of data from the MPU through the output interface to the display shall result in the display of each character in its non-inverted state.

e) A keyboard shall be provided. The transfer of data from the keyboard by way of the input interface to the MPU shall result in each character being received in its non-inverted state. The character shall consist of four bits of binary data, while the character control shall consist of one bit. A low state on the character control to the interface shall indicate the presence of a valid character. Each key shall: be engraved or embossed with its function character; have a minimum surface area of 0.075 square inch (48 mm2); be mounted on a minimum of 1/2 inch (12.7 mm) centers; have an actuation force between 0.1 and 0.2 lbf (0.5 and 1.0 N); and, provide a positive tactile indication of contact. Key contacts shall: have a design life of over 1,000,000 operations; be rated for the current and voltage levels used; and, stabilize within 5 milliseconds following contact opening.

f) The front panel shall be provided with a toggle LOGIC switch to enable the STOP timing function and shall be labeled "STOP TIMING."

g) An ON/OFF toggle CONTROL switch and fuse shall be provided for AC power. The switch and fuse shall protrude through the front panel, but not be attached (remain with the controller unit chassis when the front panel is removed). The fuse shall be a 3AG Slow Blow type, rated at either 1 or 2 amperes dependent upon the controller unit power requirements.

h) The front panel, under the legend "OPERATING INSTRUCTIONS," shall include a framework to retain a card, 4 inches wide by 6 inches high by 1/16 inch thick (102 mm wide by 152 mm high by 1.6 mm thick).

A671-2.15 Internal System Interface:

Lateral spacing shall be a minimum of 1.0 inch (25.4 mm) from the PCB surface to any component or surface for the Model 400 Module and 0.75 inch (19 mm) for the program module. Continuous nylon card guides (permanent locking type) shall be provided for the modules and all internal PCBs.

A PCB 22/44S connector shall be provided for the Model 400 module and a placement of the vertical M/170 connector shall be such that the program module front panel shall be flush with the Model 170E controller unit front panel when the module is connected.

A671-2.15.1 Data and Address Bus Requirements:

All data bus buffers and data bus drivers shall be tri-state buffered devices, enabling them to drive a load consisting of ten gates and 200 picofarads. The propagation delay time shall be less than 30 ns. All address bus inputs shall be buffered and shall load the bus by one TTl gate load and 100 picofarads.

A671-2.15.2 Connector Requirements:

Connector C1S shall be mounted on the controller unit providing 44 inputs and 56 outputs of control interface to and from external devices or files.

A671-2.15.3 Communication System Interface:

The communication system shall consist of the CPU, ACIA, motherboard connectors and lines, Model 400 MODEM module and interfaces between the ACIA & MODEM and both MODEM & ACIA to C2S Connector/T-1 Terminal. The interface between the ACIA and MODEM shall comply with EIA RS¬232-C Standards and all functions under T-1 and C2 Connectors are referenced to the MODEM. The RTS and TX data lines to the MODEM shall have MARK and SPACE voltages of -12 and +12 V DC, respectively.

A671-2.16 Electrical Requirements:

The front panel and chassis shall be connected to an equipment ground. A surge arrestor shall be provided between the AC+ and AC- for protection against power line noise transients. The surge arrestor shall meet requirements as outlined in Figure A671-8.1.

FIGURE A671-8.1

POWER LINE NOISE TRANSIENT SURGE ARRESTOR

Recurrent peak voltage:	212 volts
Energy rating maximum:	20 joules
Power dissipation, average:	0.85 watt
Peak current for pulses less than 6 us	2000 amperes
Standby current:	Less than 1 mA

Two 0.5 ohm, 10 watt wire-wound power resistors with a 0.2 μH inductance shall be provided (one on the AC+ power line and one on the AC- line). Three surge arresters rated for 20 joules shall be supplied between AC+ and ground, AC- and ground and between AC- and AC- coming off the 0.5 ohm resistor going to the surge arresters.

The AC power to the controller unit shall be supplied by a three conductor cables at least 3 feet in length. The cable shall terminate in a NEMA Type 5-15P grounding type plug.

Test points shall be provided for monitoring all power supply voltages. All test points shall be readily accessible when the front panel is opened. Any provided test point shall be isolated such that attaching a test probe shall not impact the operation of the controller unit. The test points shall be post type, 1/16 inch diameter and 3/16 inch high, minimum. The clearance between test points and other components shall be 1/4 inch, minimum.

A671-2.17 Program Module (MODEL 412C):

The following (but not limited to) manufacturer's program modules, as listed below, shall be considered approved modules per the specifications.

MANUFACTURER	PROGRAM MODULE
Automatic/Eagle Signal	412C
McCain Traffic Supply	412C
Peek Traffic/Signal Control Company	412C
SafeTrans Traffic Systems, Inc.	412C

A device shall be provided to prevent the module, when inserted upside down, from making contact with the module's mating connector within the controller unit.

The module PCB connector shall be provided with electrostatic charge protection to prevent complementary metal oxide semiconductor (CMOS) device damage.

The program module shall be MODEL 412C, including backup lithium battery and real-time clock adjuster circuit. One PROM module shall be provided for each controller delivered.

The Module PCB connector shall be a PCB 37/72P.

The module front panel shall be connected to equipment ground at M/170 Pin 34.

All addressable devices shall be fully decoded.

A671-2.17.1 Bus Inputs and Outputs:

a) All data lines shall be tri-state buffered on the module enabling them to drive a load consisting of ten gates and 200 picofarads. When this module is not being addressed, the data output lines shall be disabled into a high impedance state and the data lines shall not source or sink more than 100 µA.
b) All address input lines shall load the bus by a maximum of one TTL gate load and 100 picofarads. The propagation delay time shall be less than 30 ns.

A671-2.17.2 Memory Sockets:

Three memory sockets shall be provided and fully decoded. Up to eight different memory map configurations shall be accommodated by this module. Each of these configurations shall be selected by user inserted jumper wires. The first two memory maps shall be defined as shown in Figure A671-9.2, and the remaining six memory maps shall be undefined and reserved for future use.

FIGURE A671-9.2

MEMORY MAPS #1 & #2

Memory Socket Address Range and Device				Jumper Pattern		
Map	U2	U2	U3	#1	#2	#3
1	8000-FFFF	7000-7FFF	0800-7FFF	OUT	OUT	OUT
2	A000-FFF	8000-7FFF 7000-7FFF	0800-4FFF	IN	OUT	OUT

Jumper positions for Sockets U2 and U3 shall be provided to convert the sockets from an EPROM socket from a non-standby power socket to a standby power socket or visa versa. Sockets U2 and U3 shall be jumped for non-standby power.

A671-2.17.3 Module Power Supply:

A power supply shall be provided on-board the module consisting of a DC regulation circuit, standby power, and all necessary support circuitry.

DC regulator device with its circuitry shall be provided to reduce the +12 V DC to +5 V DC for module use. The regulator shall have a minimum efficiency of 75 percent and provide +5 (± 0.25) V DC from no load to full load with a maximum of two percent ripple.

All RAM devices shall be NOVRAM-type only.

A671-2.17.4 Computer Chip Population:

Each delivered module shall be fully populated for operating the software specified.

It shall be provided in configuration 4 (memory select 4), as stated below.

Mapped to:

UI 32 KB EEPROM as INT27256A CMOS	Mem. 8000-FFFF
U2 8 KB NOVRAM (zero power) as DAL1225	Mem. 3000-4FFF
U3 8 KB NOVRAM (zero power) as DAL1225	Mem. 7010-7FFF
U4 8 KB RAM as HD 6262	Mem. 1000-2FFF

The "Jumper Pattern" shall be set accordingly.

All integrated circuits having 14 pins or more, shall be socket mounted as described in the paragraph "Integrated Circuits". In addition, sockets for PROMS, EPROMS, and EEPROMS shall be low insertion/withdrawal force lock type.

A671-2.18 Modem

The modem shall be a MODEL 400. All integrated circuits having 14 pins or more, shall be socket mounted as described in the paragraph "Integrated Circuits".

A671-2.19 170 Controller Assembly Functional Software Specification

A671-2.19.1 Description

The 170 Traffic Controller Assembly shall be delivered to operate in a pre-timed, semi-actuated and fully actuated controller operation. The software shall be provided as an integral part of the traffic controller cabinet assembly and shall meet the functional requirements as established in these specifications. Additional system software shall be included in the project specific requirements and shall be reviewed and approved for that project.

A671-2.19.2 Prom Module Requirements

The software program shall provide the functions and features described in this specification and shall be contained in erasable programmable read-only memory (EPROM) on the program module.

A671-2.19.3 Non-Volatile Storage Requirements:

All user-programmable setting shall be maintained in a non-volatile memory. Battery-backed RAM is not acceptable as a non-volatile storage medium.

A671-2.19.4 Basic Communications Functionality:

The software shall be fully compatible with existing central computer operations, and/or existing closed-loop computer operations, and/or hybrid systems.

A671-2.19.5 Modes of Operation:

The controller shall be capable of operating in pre-timed, semi-actuated or fully-actuated modes, as well as coordinated, isolated and flash modes.

A671-2.19.6 Timing Accuracy:

The accuracy of each timed interval shall be within 100 milliseconds of the programmed value.

A671-2.19.7 I/O Re-assignments:

For purposes of providing maximum flexibility, all C1 connector inputs and outputs, with the exception of the watchdog output, shall be re-assignable by the user, either from the 170E controller front panel or a field transportable unit (FTU [or laptop computer]) interface.

A671-2.19.8 Initialization:

All user-programmable timing and parameters shall be maintained in non-volatile storage for transfer into working RAM during initialization. If during initialization an error in the data integrity is discovered (e.g., check sum error), the program shall not toggle the watchdog timer output (Voltage Monitor output stays false [hi state]).

A671-2.19.9 Data Integrity:

The program shall continuously monitor the electrically erasable programmable read only memory (EEPROM) and RAM of the controller unit. If an error is detected, the watchdog output shall not toggle, causing the intersection to go to flash.

A671-2.20 Local Intersection Control:

A671-2.20.1 Inputs:

A671-2.20.2 Number and Type of Inputs:

The following inputs are to be provided, at a minimum:

(a)	4	Pedestrian Calls	(j)	1	Phase Force-Off
(b)	18	Vehicle Detectors	(k)	1	Phase Hold
(c)	4	Emergency Vehicle Preemption Requests	(l)	1	Call to Non-Actuated
(d)	2	Railroad Preemption Request	(m)	1	Stop Timing
(e)	1	Pre-timed Mode	(n)	1	Manual Control Enable
(f)	1	Flash Request (UCF)	(o)	1	Interval Advance
(g)	1	Flash Sense	(p)	1	Maximum Termination Inhibit
(h)	1	Exclusive Pedestrian Omit	(q)	3	Phase Omit Group
(i)	1	External Clock Reset	(r)	1	Phase Actuation Control

Input assignments shall be programmable (*See* next section).

A671-2.20.3 Input Assign ability:

All inputs may be re-assigned by the user, either via front-panel controls or an FTU interface program.

A671-2.20.4 Functional Description of Inputs:

The functional operation of each of these inputs is defined as follows:

a) **Pedestrian Call Inputs:** Each input may be assigned to a vehicle phase for concurrent operation. When in exclusive pedestrian mode, the call will be reassigned to the exclusive pedestrian movement. Exclusive pedestrian mode is discussed in the subarticles of A671-1.
b) **Vehicle Detectors:** Discussed in subarticles of A671-1.
c) **Emergency Vehicle and Railroad Preemption Inputs:** Discussed in Section A671-1.18.
d) **Pre-timed Mode:** When true, this input causes the controller to operate in a pre-timed mode. Pedestrian Walk time shall vary as the splits or cycle length changes. The pedestrian Walk time shall not be reduced below a preset minimum time.
e) **Flash Request and Flash Sense:** Discussed in the subarticles of A671-1.
f) **Exclusive Pedestrian Omit:** Discussed in the subarticles of A671-1.
g) **External Clock Reset:** The Clock Reset input, when true for a minimum of one second, shall cause the time-of-day clock to reset to a user-programmable time-of-day
h) **Phase Hold:** Used to retain the existing right-of-way and cause different controller responses depending upon operation in the non-actuated or actuated mode.
    1) For a non-actuated phase, activation of the Hold input shall maintain the controller unit in the timed-out Walk period with a Green and Walk indication displayed. Activation of the Hold input while timing the Walk portion of the Green interval shall not inhibit the timing of this period. Deactivation of the Hold input, with the Walk interval timed out, shall cause the controller unit to advance into the Flashing Don't Walk interval. Re-application of the Hold input while timing the Flashing Don't Walk portion of the Green interval shall neither inhibit the timing of this period nor cause termination of the phase.
    2) For an actuated phase, activation of the Hold input shall allow the controller to time normally, but shall inhibit its advance into the vehicle clearance interval. Activation of the Hold input shall inhibit the recycle of the pedestrian service. The rest state signal indications for the phase shall be Green for traffic and steady Don't Walk for pedestrians.

3) Deactivation of the Hold input with all intervals timed out shall allow the controller unit to recycle the Walk interval if there is no conflicting demand for service and a pedestrian call exists for that phase. However, if there is any serviceable demand on any opposing phase with the Hold input deactivated, with all intervals timed out, the controller unit shall advance into the vehicle clearance interval and not recycle the Walk on that phase until those demands have been served.

i) **Force-Off:** Used for termination of the Green timing and/or Walk in the non-actuated mode of the active phase in the timing ring, subject to the presence of a serviceable conflicting call. The Force-Off function shall not be effective during the timing of the Initial, Walk, or Flashing Don't Walk intervals. The Force-Off input shall be effective only as long as the input is sustained.

j) **Inhibit Maximum Termination:** Used to disable the maximum termination functions of all phases in the selected timing ring. The input shall not inhibit the timing of Maximum Green.

k) **Stop Timing:** Used to cause cessation of controller unit ring timing for the duration of such activation. Upon removal of activation from this input, all portions which were timing will resume timing. During Stop Timing, vehicle actuation shall reset the Gap Timer in the normal manner; the controller unit shall not terminate any interval or interval portion or select another phase, except by activation of the Interval Advance input. Operation of the Interval Advance input with Stop Timing activated shall clear any stored calls on a phase when the controller unit is advanced through the green interval of that phase.

l) **Interval Advance:**

1) Complete On-Off operation of this input shall cause immediate termination of the interval in the timing process. Where concurrent interval timing exists, use of this input shall cause immediate termination of the interval which would terminate next without such activation.

2) Phases without stored vehicle or pedestrian calls shall be omitted from the resultant phase sequencing of the controller unit unless the Manual Control Enable input is activated.

3) The controller unit shall select the next phase to service based on its normal sequence control method. If Interval Advance is activated during the Green interval and no serviceable call exists, the controller unit shall not advance beyond the Green dwell state, except when Red Rest is active.

4) If Interval Advance is applied when the unit is displaying Green and Walk indications, the unit shall advance to the state of displaying Green and Flashing Don't Walk. If Interval Advance is applied when the unit is displaying Green and Flashing Don't Walk, the unit shall display a steady Don't Walk and advance to

the Green dwell state, from which it shall immediately select a phase next and advance to Yellow, subject to the presence of a serviceable conflicting call and the constraints of concurrent timing.

5) If no pedestrian provisions exist, application of the Interval Advance signal at any point in the Green interval shall cause the unit to advance to the Green dwell state from which it shall immediately select a phase and advance to Yellow, subject to the presence of a serviceable conflicting call and the constraints of concurrent timing.
6) Manual Control Enable is used to place vehicle and pedestrian calls on all phases, stop controller unit timing in all intervals except vehicle clearance intervals, and inhibit the operation of Interval Advance during vehicle clearance intervals. When this input is used, in conjunction with Interval Advance, the operation of the controller unit shall be as follows:
   i) When concurrent pedestrian service is not provided, one activation of the Interval Advance shall advance the controller unit to the end of Green timing, where it shall immediately select a phase next and advance to Yellow, subject to the constraints of concurrent timing.
   ii) When concurrent pedestrian service is provided, two sequential activations of the Interval Advance input shall be required to advance through a given Green interval. The first actuation shall terminate the Walk interval, and the second shall terminate the Green interval, including the Flashing Don't Walk interval.

m) **Call to Non-Actuated Mode:** This input, when activated, shall cause any phase(s), so programmed, to operate in the Non-Actuated mode. These phases shall have a permanent demand placed for vehicle and pedestrian service, while the Call to Non-Actuated Mode is true.
n) **Phase Omit Group:** Each phase omit group can be user-selected to omit a minimum of four phases. The phase omit groups shall be activated by result of a combination of three inputs.
o) **Phase Activation Control:** Provisions shall be made to place a minimum of four phases on Maximum Recall. Provisions shall be made to internally force-off the phases selected after the Minimum Green interval has timed out. The phase actuation control shall be activated by result of a combination of three inputs.

A671-2.20.5 Outputs:

A671-2.20.6 Number and Type of Outputs:

The following outputs are to be provided, at a minimum:

(a)	8	Phase Green	(f)	4	Overlap Green Arrows

(b)	8	Phase Yellow	(g)	4	Overlap Yellow Arrows
(c)	8	Phase Red	(h)	1	Flash Status
(d)	4	Pedestrian Walk	(i)	1	Preemption Status
(e)	4	Pedestrian Flashing Don't Walk	(j)	1	Watchdog Status

A671-2.20.7 Output Assign Ability:

With the exception of the Watch Dog Status output, all outputs may be reassigned by the user, via either the front-panel keyboard or the FTU interface program.

A671-2.20.8 Phase Timing Intervals:

A671-2.20.9 Per Phase Intervals:

The following intervals are to be provided on a per phase basis:

(a)	Walk	(g)	Minimum Gap
(b)	Flashing Don't Walk	(h)	Maximum Green
(c)	Type 3 Detector Limit	(i)	Reduce Gap By
(d)	Added/Vehicle	(j)	Reduce Gap Every
(e)	Vehicle Extension (Gap)	(k)	Yellow Change
(f)	Maximum Gap	(l)	Red Clearance

A671-2.20.10 Per-Controller Intervals:

These intervals shall be provided on a per-controller basis:

a) Maximum Initial
b) Red Revert

A671-2.20.11 Phase-Interval Timing Ranges:

The controller unit shall be capable of the following phase timing intervals:

Interval	Range	Increment
Walk	0-255	Second
Flashing Don't Walk	0-255	Second
Minimum Green	0-255	Second
Type 3 Detector Limit	0-255	Second
Added per Vehicle	0-25.5	Tenths of a Second
Vehicle Extension (Gap)	0-25.5	Tenths of a Second

Minimum Gap	0-25.5	Tenths of a Second
Minimum Gap	0-25.5	Tenths of a Second
Maximum Green	0-255	Second
Reduce Gap By	0-25.5	Tenths of a Second
Reduce Gap Every	0-25.5	Tenths of a Second
Yellow Change	3.0-6.0	Second
Red Clearance	0-25.5	Tenths of a Second
Maximum Initial	0-255	Second
Red Revert	0-25.5	Tenths of a Second

A671-2.20.12 Phase Timing:

The controller unit shall be capable of the following phase timing intervals:

a) **Green Interval without Volume Density**
   1) **Minimum Green** - The first timed portion of the green interval; guaranteed minimum green time for the phase.
   2) **Vehicle Extension (Gap Timer)** - Vehicle actuations reset this timer, and it begins timing when the vehicle actuation is removed. This extension period is subject to termination by the Maximum Extension Timer or by being Forced-Off.
   3) **Maximum Green** - Determines the maximum length of time that this phase may be held in green in the presence of an opposing call. The timer starts at the end of the initial Minimum Green interval, in the presence of an opposing call. If there is no opposing call, it will be reset, until an opposing call occurs.

b) **Green Interval with Volume Density (Reference Figure 673-11.2)**
   1) **Extensible Initial** - This interval times concurrently with the Minimum Green interval, and is capable of being increased for each vehicle actuation (users setting from 0 to 25.5 seconds per actuation) received during the yellow and red displays for the phase. The initial green time portion is the greater of the minimum green or extensible initial intervals, and may not exceed the setting of the Maximum Initial interval.
   2) **Extension (Gap)** - Vehicle actuations reset this timer and it begins timing when the vehicle actuation is removed. This period is affected by reducing the allowed gap between successive vehicle actuations from the Maximum Gap to Minimum Gap and Reduce Gap Every intervals. This gap reduction relates to the arrival of the first opposing vehicle actuation. Upon the expiration of the gap timer, the

phase will terminate. This portion of the green can be terminated by a Maximum Green time-out, or by being Forced-Off.

c) Pedestrian Interval

1) The pedestrian indications are output concurrently with the assigned vehicle phase. If there are no opposing calls, the pedestrian interval may be recycled in response to a pedestrian actuation or recall.
2) Walk - This period controls the amount of time the Walk indicator is displayed.
3) Flashing Don't Walk - This controls the duration of the Flashing Don't Walk period.

d) **Termination of Green:** Phase Green will terminate due to one of the following conditions:

1) There is an opposing call present; the guaranteed minimum green interval has timed out; pedestrian timing (Walk and Flashing Don't Walk) has timed out and:
   i) Extension time or Reduced gap has timed out, or,
   ii) Maximum extension has timed out.
2) Red Rest is programmed; there are no opposing calls; the guaranteed minimum green interval and pedestrian timing have timed out; and recall is not set for this phase.
3) The phase has received a force-off and the initial green interval and pedestrian interval have timed out.
4) If a phase terminates by maximum or force-off, a call will be placed on it.

e) **Vehicle Clearance Intervals:**

1) Following the green interval of each phase, there is a Yellow Change interval which is timed according to the yellow timing for that phase. Any timing for yellow less than 3.0 or greater than 6.0 seconds shall be ignored and the controller shall automatically time either 3.0 or 6.0 seconds, respectively.
2) Following the Yellow Change interval of each phase, the controller may time a Red Clearance interval for the programmable phase. During this timed interval, no green will be shown to any conflicting phase. The Red Clearance interval shall be timed for the amount of red clearance timing for that phase.
3) A Red Revert interval shall follow the Yellow Change interval whenever the controller immediately returns to the phase just serviced. The Red Revert timer must complete its timing prior to re-servicing a phase.

A671-2.20.13 Phase Functions

a) Programmability:
The following functions shall be programmable on a per-phase basis:

(1) Permitted Phases (7) Red Rest

(2) Detector Red Lock	(8) Double Entry Phase
(3) Detector Yellow Lock	(9) Vehicle Maximum Recall
(4) Vehicle Minimum Recall	(10) Conditional Service
(5) Pedestrian Recall	(11) Non-Actuated Mode
(6) Pedestrian Enable	(12) Startup Phases

b) Phase Function Operations:

1) **Permitted Phases:** This function selects the phases to be allowed at the intersection. Only permitted phases will accept detector input and provide output timing.
2) **Detector Red Lock:** Provides vehicle detector memory for a phase when that phase is in red. Vehicle calls placed and cleared during yellow will not be locked in.
3) **Detector Yellow Lock:** Provides vehicle memory for a phase when that phase is in yellow or red. Vehicle calls during yellow and red will be locked in. If neither Red Lock nor Yellow Lock is activated for the phase, the detector input will be in the non-lock mode.
4) **Vehicle Minimum Recall:** Recalls a phase to time the Minimum Green interval.
5) **Pedestrian Recall:** Recalls a phase to time the Walk and Flashing Don't Walk intervals.
6) **Pedestrian Enable:** Pedestrian movements will be permitted on selected phases only.
7) **Red Rest:** Causes a phase to terminate even in the absence of a conflicting call and if there is no recall on for the phase. A Red Revert time must be timed before the same green can be displayed again.
8) **Double Entry:** Double entry causes two separate Ring "A" and Ring "B" signal indications to turn on concurrently (e.g., phases 4 and 8) even if there is no recall on for the phase. For example, a selected Ring "B" phase will also be output when a concurrent selected Ring "A" phase is being served if there is no other concurrent phase demand in Ring "B".
9) **Vehicle Maximum Recall:** Places a continuous call on the selected phase to extend the phase to its maximum limit. Maximum time for a phase is the sum of the Minimum Green plus the Maximum Extension.
10) **Conditional Service:** Tagged phases shall operate according to the specifications of Conditional Service, detailed in Subject A-B, 3.10
11) **Non-Actuated Mode:** Selected by phase through the keyboard or through the use of the FTU interface. When a phase is selected, the following occurs:
    i) A Vehicle Minimum Recall is placed on that phase.

ii) If the phase has a pedestrian feature, it shall recall the pedestrian movement, the phase will "Rest in Walk at the End of the Walk" interval when there are no opposing calls.

12) **Start-Up Phases**: Tagged phases will startup in the Yellow interval following a long power failure (2 seconds or longer). If no phases are tagged, an All Red startup interval will be timed before servicing calls. The length of the All Red interval is the sum of the phase 4 and 8 yellow and red clearance intervals. At startup, pedestrian calls are placed on any permitted through phases.

A671-2.21 Power-Up / Power-Down Operations:

a) Following power failures of less than two seconds in duration, the controller shall resume timing from the interval that was on just prior to the outage. All timers shall be the same as before the interruption, excepting the extension timer for the interrupted green phase, which shall be reset.

b) A long power outage (more than two seconds, or recovery from Flash) shall cause the controller to revert to its start-up sequence. The start-up sequence begins with a Yellow output of selected phase(s). If no phases are selected for Yellow start-up, the controller shall start in All Red.

A671-2.22 Preemption Operation:

A671-2.22.1 General:

a) Controller preemption shall be an internal function of the controller unit.

b) The prioritized order of preemption calls shall be as follows:
   1) Railroad
   2) Bridge
   3) Fire

A671-2.22.2 Preemption Design and Operation:

a) **General Operation:**

The following is the required preemption operation during the period immediately after the preemption call is received in the controller cabinet.

1) The preemptor shall interrupt all external commands to and from the controller to insure absolute control of the street traffic operations.
2) There shall be no flickering of street signals due to the transition to preemption control of the intersection, during the preemption period, or during the transition out of preemption.
3) The preemption period shall be protected such that it shall not release until in the preemption dwell phase. Discontinuity in the call signal of less than three seconds after the beginning of dwell, shall not terminate the preemption operation.
4) Preemption shall operate without the use of additional (dummy) phase(s) which will require programming and interval timing to be input by the maintaining agency.
5) Exclusive preemption minimum timing shall be provided for the intervals listed in Figure A671-11.3 which can be set/programmed by the maintaining agency, as desired. Preemption minimum timing shall monitor the controller intervals during normal intersection operation. Upon receiving the preempt command, the elapsed time for the interval involved shall be compared to the preemption minimum timing and the preempt control logic defined in Figure A671-11.4.
6) A preempt call in any interval shall direct the controller into the clearance phase and not allow any other phase to be timed. All clearance and dwell phases shall be completely user programmable.

FIGURE A671-11.3

EXCLUSIVE PREEMPTION MINIMUM TIMING

Controller Interval/Display When Preemption Call is Received	Exclusive Preemption Minimum Time Before Starting Preemption Sequence
WALK	Display Flashing Don't Walk Interval from0 to 10 seconds
FLASHING DON’T WALK	Display Flashing Don't Walk Interval from0 to 10 seconds
MINIMUM GREEN	Display Green Interval from 5 to 10 seconds
YELLOW	Display Yellow Clearance Interval from3 to 5 seconds
ALL RED	Display the All Red Indication for 0 to 3 seconds

FIGURE A671-11.4
EXCLUSIVE PREEMPTION MINIMUM TIMING

Controller Interval Time	Preempt Control
LESS THAN PREEMPT MINIMUM TIME	Continue Controller Interval Timing until it is equal, then execute preempt control sequence as programmed
EQUAL TO PREEMPT MINIMUM TIME	Execute preempt control sequence as programmed
GREATER THAN PREEMPT MINIMUM	Execute preempt control time sequence as programmed

b) **Specific Operation:**
1) **Railroad preemption**: If the controller happens to be displaying the preempt dwell indications at the time the preempt signal is received, these indications will continue to be displayed until the end of the preempt swell, unless the preemption programming calls for a track clearance interval in the preemption sequence. In this case, yellow will be displayed to the active phase(s). This will be followed by the track clearance display and return to the preempt dwell display.
2) **Bridge preemption**: If the controller happens to be displaying the preempt dwell indications at the time the preempt signal is received, these indications will continue to be displayed until the end of the preempt dwell, unless the preemption programming calls for a bridge clearance interval in the preemption sequence. In this case, yellow will be displayed to the active phase(s). This will be followed by the clearance display and return to the preempt dwell display.
3) **Fire preemption**: If the controller happens to be displaying the preempt dwell indications at the time the preempt signal is received, these indications will continue to be displayed until the end of the preempt dwell. At the end of the preemption dwell, vehicle calls shall be placed on all minor phases of the controller. The preemptor shall maintain the call to each minor phase during the signal cycle following the preemption operation until the minimum green on each phase begins. At the time the minimum green begins on a phase, the vehicle call placed on that phase by the preemptor shall be dropped.

A671-2.23 Flash Operations:

a) Uniform Code Flash shall be an internal function of the controller unit; shall not be inhibited by the HOLD command; and no external logic shall be used to provide this function.

b) A "True" signal on the Flash Request input shall cause the controller to transfer from normal operation to flashing operation only at the end of the common Major Street Red Interval, the Common Minor Street Yellow Interval, or the All Red Interval. During Flash, the controller shall hold the Flash Status output "True".
c) The flash state of phase and overlap outputs shall be programmed (Flash Yellow, Flash Red or Dark) from the front panel of the 170E controller or via the FTU interface.
d) The transfer of the controller assembly from flashing operation to normal operation shall cause the controller unit to revert to its start-up sequence following a "False" Signal on the Flash Request input.
e) The Flash Sense input shall be monitored by the local intersection software. When "True", the controller shall monitor for a "False" condition. When the input has been "False" for a period of one second, the controller shall immediately revert to a start-up sequence.

A671-2.24 Pedestrian Operations:

A671-2.24.1 General:

In addition to standard Walk and Flashing Don't Walk timing, it shall be possible to specify a phase to operate with either an Advanced or Delayed Walk interval. If the phase is programmed to have an Advanced Walk, the Walk indication shall begin before the concurrent Phase Green interval timing. If a phase is programmed to have a Delayed Walk interval, the Walk indication shall be delayed to begin after the start of the concurrent Phase Green interval timing.

A671-2.24.2 Exclusive Pedestrian Mode:

The Exclusive Pedestrian Omit input controls the Exclusive Pedestrian mode as follows:

a) When "True", all pedestrian movements are concurrent with their associated vehicle phases.
b) When "False", all pedestrian calls are served by the exclusive pedestrian phase. The exclusive pedestrian phase shall follow the main street through movement, and shall have separately programmable settings for Walk, Flashing Don't Walk and Red Clearance. During this phase all pedestrian indications shall be active simultaneously.
c) During pre-timed mode, the controller shall provide for both concurrent and exclusive pedestrian indications. The Walk indication for a specific movement will "Overlap" between the exclusive pedestrian Walk interval and the concurrent pedestrian Walk interval, when those movements directly follow each other.

A671-2.25 Overlap Requirements:

A671-2.25.1 General:

A minimum of eight overlaps shall be provided. Each overlap shall be separately programmable as to type (Pedestrian, Left Turn, Right Turn, Protected/Permissive, and 4-head or 5-head logic). All overlaps shall be programmable as to the vehicle and/or pedestrian phases assigned to each.

A671-2.25.2 Programmability:

Provisions shall be made so as to allow time-of-day switching between Protected only and Protected/Permissive operations.

A671-2.25.3 Overlap Phase Inhibit:

Provisions shall be made to allow the user to inhibit a vehicular or pedestrian phase when the overlap operates.

A671-2.25.4 Protected-Permissive:

Whenever intersection control requires a left turn green arrow and green ball control logic for protected-permissive left turn indications, logic shall be provided to transfer the left turn vehicle detection to its concurrent through movement phase when the left turn is controlled by a green ball indication. At all other times, the left turn detection shall be directed to its associated phase. Left turn detection for Left Turn Green Arrow-green control shall be directed to its associated phase in the event through movement detector transfer occurs.

A671-2.25.5 Detector Operations:

a) **Modes, Types, and Number:** A minimum of 26 vehicle detector channels shall be provided. Each detector channel may be assigned to either or both (simultaneously) of two modes from the front panel of the controller or from the FTU interface:

   Mode 1:"Local Actuation Detection", for the purpose of placing calls on actuated phases.

   Mode 2:"System Sensors", for the purpose of measuring volume and occupancy for the eventual purpose of uploading that data to a central site.

   Mode 3:"Stop Bar Detection", for the purpose of detecting a vehicle at the stop bar anytime the vehicular phase is red and up to the point in the green interval when the detection area is vacant or the maximum limit, specified by the Type 3 Disconnect Interval, has been reached. The detector, at that point in time, shall cease to detect vehicles until the phase returns to the red interval.

b) **Programmability:**
The mode of operation and the channel assignment shall be programmable through the keyboard or through the FTU interface.

c) **Mode 1 Types:**
Mode 1 detectors shall be of these types:

Calling and Extending Detector: An Actuation on this detector will reset the Extension timer when the phase is green, and place a call on the phase at all other times.

Calling Detector: An Actuation on this type of detector will place a call on the associated phase only when the phase is red. Calling detectors may also be designated as Type 3 detectors. A detector so designated shall input an extension call during the green interval until the actuation ceases or the maximum limit, specified by the Type 3 Disconnect interval, has been reached. Additional calls shall not be accepted even if the original call drops out before the Type 3 Disconnect time has expired. When the timer expires, the Call Only detection shall not be active again until the red interval.

Extending Detector: An Actuation on this type of detector will place a call on the associated phase only when the phase is green.

Detectors shall also have a Carry feature. This feature causes the controller to continue to place a vehicle actuation on the associated phase after the vehicle has left the detection area during the phase green. The Carry Time is adjustable from 0-25.5 seconds in 0.1 second increments.

d) **Mode 2 Sensing:**
In Mode 2 operation, each detector shall sense occupancy by counting at the rate of 30 "ticks" per second when a vehicle is over the detector loop. When an accumulator of these ticks for each system detector reaches a count of 30, a bit will be set in an occupancy output buffer. This buffer is associated with the "new" system concept. For purposes of this specification, it is sufficient to have the clocks and the counters sufficient for eight system detectors in the software.

e) **Mode 3 (Stop Bar) Detection:**
In Mode 3 operation, each detector shall accept calls only during the phase red. When a call is detected, it is held through the green until the detection area is empty. The extend timer begins timing with the phase green. If a call is received before the

extend timer times-out, the timer will reset. Timer reset will continue to occur until a gap between the calls is large enough to allow the extend timer to time-out or the Mode 3 timer expires first. Once the time-out occurs, no further calls are accepted until the phase returns to red.

f) **Data Quality Monitoring:** Provisions shall be made to monitor vehicle detectors, when in Mode 1 usage, for both "stuck-on" and "stuck-off" conditions. Low and high counts at thresholds for these conditions shall be user programmable through the keyboard or the FTU interface.

Failure of any detector assigned to an intersection shall cause a bit to be set to the "True" condition. This condition shall then be assigned to a spare C1 connector output. This condition will be returned to central as an indication of detector quality. The spare C1 connector pin to be used for this purpose shall be assigned by the engineer.

In addition, the channel number of the failed detector shall be inserted into a buffer. Data in this buffer shall be uploaded to the FTU interface so that the failure is readily available to the maintenance technician. However, its purpose is to be uploaded to central at some later time.

A671-2.26 Special Requirements:

A671-2.26.1 Manual Control Enable during Flash:

During Time-Based Flash operations, a true signal on the Manual Control Enable input shall cause the controller to drop out of flash and revert to free-run mode.

A671-2.26.2 Protected/Permissive Overlap Logic:

Special logic will be included which will prohibit a Protected/Permissive phase from returning to protected operation once into the permissive operation.

A671-2.26.3 Conditional Service:

It shall be possible to service phases designated as "Conditional Service" twice in a controller cycle. A Conditional Service phase shall be served after the corresponding lag phase even though a cross barrier call exists if sufficient maximum time remains on the concurrent phase to allow the Conditional Service phase to serve its minimum green. When a phase is conditionally served, its maximum timer shall be set to the maximum time on the concurrent phase.

A671-2.26.4 Advance Warning Beacons:

Two output circuits shall be provided which can be energized just prior to an associated phase terminating to yellow and will stay on until the associated phase next becomes green. The time before Yellow and the associated phase shall be operator assignable for each output.

A671-2.27 Local Coordinated Operations

A671-2.27.1 Description

The local coordination program shall provide for both manual and Time-of-Day/Day-of-Week (time-based) selection of signal control (timing) plans. Manual control shall have priority over remote or time-based coordination. During coordinated operations, phases shall not terminate due to maximum green time-out.

A671-2.27.2 Operations Manually or Time-of-Day/Day-of-Week Selected:

The following functions shall be programmable on a Time-of-Day/Day-of-Week basis or shall be manually selected through the keyboard or FTU interface:

a) Timing Plans, including Permissive Periods/Yield Points.
b) Concurrent versus exclusive pedestrian modes.
c) Phase Sequence, including phase lagging, by phase pair.
d) Protected only vs. Protected/Permissive Overlaps.
e) Permitted Phases.
f) Conditional Service.
g) Recalls (minimum, maximum and pedestrian).
h) Eight independent outputs.
i) It shall be possible to select any one or all phases to operate by itself within the normal phase sequence.
j) It shall be possible to prohibit normally compatible phases from displaying concurrently.
k) It shall be possible to split Ring "A" and Ring "B" to operate independently of each other.
l) Provision shall be made to allow an intersection to transform to/from a half quad configuration to/from a split phase configuration on a Time-of-Day basis.

A671-2.27.3 Timing Plan Features and Functions:

a) **Cycle/Split/Offset:** A minimum of nine plans, each with three separate offsets, are to be provided. If plan numbers are replaced by cycle-split designations, a minimum of four cycles and four splits are to be provided. The cycle length and offset time shall be in seconds and shall be adjustable from 0 to 255 seconds in one-second increments.

The offset establishes a time relationship between the local cycle timer and the master cycle timer to provide a progression of traffic flow through the system. The offset shall be measured in seconds from the system synchronization point (master zero) and the local yield point (local zero). All synchronization points are referenced from 12:00 midnight or 00:00 hours.

b) **Permissive Periods/Yield Points:** A minimum of three permissive periods are to be provided. Each permissive period may be associated with any vehicle or pedestrian phase. The start time for permissive period one shall be the yield point. In addition, a synchronization phase pedestrian permissive period shall be provided that allows pedestrian demands on the synchronization phases to be served, even though there are no opposing calls, if enough time remains before the yield point.

Permissive periods and force-off points shall be expressed in seconds, from 0 to 255 seconds, in one-second increments.

A671-2.27.4 Time-based Scheduler:

A minimum of 32 time-of-day events shall be provided to change any of the functions listed in Section 673-11.4.2. The events shall be capable of being implemented on any, all or any combination of days of the week.

A minimum of 32 holidays shall be provided for in the Time-based Schedules, which shall cause a different time-of-day schedule to be implemented on designated days.

A minimum of 32 special events shall be provided for in the Time-based schedules.

A671-2.27.5 Time-of-Day Clock:

The time-based scheduler shall reference all plan changes from an internal time-of-day clock. This clock shall be set either from the keyboard or from the FTU interface. Daylight saving time adjustments are to be made automatically. Leap year corrections are to be made automatically. A time-of-day clock reset input, when true for a minimum of one second shall cause the time-of-day clock to be reset to a user-programmable time-of-day. A calendar rest input, when true for a minimum of one second, shall cause the day-of-week clock to be reset to a user-programmable day-of-week.

A671-2.27.6 Transitions between Timing Plans

Short way smooth offset transition shall be provided such that the cycle length will be shortened to not less than a programmed Coordination Minimum Time, until the proper offset is reached. If the controller must increase its cycle length in order to get in step or add only transition, the cycle length shall be calculated so that the controller will be in step within a programmable number of cycles. The desired split shall be maintained during transition.

A671-2.28 User Interface Requirements

A671-2.28.1 Controller Front Panel Interface

A671-2.28.1.1 *General*

The user interface with the 170E controller and this software package shall be both through the standard 170E controller keyboard and through associated FTU hardware. The user interface shall be characterized by user friendliness. With respect to the 170E keyboard/LED display combination, this implies a minimization of keystrokes and the minimization of the number of operations that must be memorized to display operational details of the display. With respect to the FTU, this implies minimization of keystrokes and clear, legible and appropriate displays on the FTU's display device.

A671-2.28.1.2 *Model 170E Controller Keyboard Operations:*

All timing values, phase functions, time-clock features, coordination and time-base functions, and all other programmable features of the software may be examined, modified and stored through the keyboard of the 170E controller. All numeric data shall be entered in decimal or base 10 notation (hexadecimal or binary base shall not be used).

A means shall be provided to allow the user to directly address the memory area of interest. Simple keyboard commands shall allow the user to scroll forward or backward through the data.

The user shall, with simple keyboard commands, be able to copy an entire phase's interval programming to another phase or phases. Similar methods shall be provided to duplicate data within fields. A means to initialize the entire controller database to a known set of default values, as well as key commands to initialize only the coordination and time-base portions of the database, shall be provided.

A671-2.28.1.3 *Model 170E Controller Front Panel Displays:*

The controller shall have numerous display modes such that the following displays are provided:

a) The present active phases and timing intervals of both rings.
b) The active phase, along with countdown display on the active interval in Ring "A".
c) The active phase, along with countdown display on the active interval in Ring "B".
d) Current coordination plan and background cycle timer display. In all display modes except when setting functions by phase, the "Call/Active" indicators numbered from 1 to 8 shall reflect vehicle calls to that numbered phase. A blinking indicator reflects a pedestrian call stored for that phase.

A671-2.28.2 FTU Interface Requirements:

A671-2.28.2.1 *Interface Capabilities:*

A software program shall be provided with the controller. The software shall provide the following capabilities:

a) A simple means to review all programmable parameters and to edit these parameters, as desired; cursor movement capabilities, as well as pop-up/pull-down menus, are examples of acceptable review and edit mechanisms.
b) Upload and download of all programmable parameters between the FTU and the 170E controller. Uploaded parameters shall be compared with the FTU originals. An obvious flag shall be used to display differences (flashing or highlighted mode).
c) Implement manual operations at the intersection (e.g., Select Timing Plan, Go to Flash, Go to Free).
d) Copying data from phase to phase, plan to plan, etc., thereby providing a means of quickly duplicating data.
e) Back up (or restoration) of any selected intersection or group of intersections database information to or from a floppy diskette, without needing to exit the program.
f) Export an individual intersection database in ASCII format to a spreadsheet program, such as Lotus 1-2-3® or Microsoft Excel® or approved equal.
g) A user selected order for printing by logical data group. User shall be able to specify order of printing of timing sheets. Each sheet shall have a user-specified footer block.
h) Override, manual, and other control functions currently active at the local controller and implement other similar functions in its place.
i) Locate an intersection without manually searching through individual files.
j) Addresses of individual intersections shall be a minimum four digit intersection (asset) number or equivalent. The numbering scheme shall be compatible with the

maintaining agency's inventory numbering scheme. Intersections may be sorted and grouped into a minimum of five separate files, for ease in database management. A single file containing all intersection databases shall not be acceptable.

k) Provide the ability to graphically create and display both section-wide and individual intersection graphics. Provide the ability to import graphic files of intersections.
l) Provide the ability to display real-time individual intersection and section wide intersection graphics.
m) The number of intersections which may be included in the FTU database program shall be limited only by the amount of available hard disk storage space on the computer.
n) The user shall be advised when adding an intersection if an asset number is already assigned.
o) A sorting option shall be provided for the intersection identification data. The data shall be sorted either by asset number or by intersection name.

A671-2.28.2.2 *Data Verification:*

Data downloaded from the FTU to the 170E controller will be automatically verified for correctness by uploading the controller data for comparison. In the event that the automatic verification process detects a discrepancy between the data transfer to the 170E controller and the data stored in the FTU computer, the FTU screen shall display all such discrepancies. All data transmissions shall be checked for integrity by the use of checksums, CRC, or other such communication fail-safe devices.

A671-2.28.2.3 *Time and Date Tags:*

Data loaded into the FTU, either from the 170E controller or some other source, shall be prefixed with time and date. This prefix shall be used by using-agency personnel to determine the most current versions of database which reside on any FTU. If off-the-shelf "version control software" is used for this task, the maintaining agency shall be provided with all necessary executable codes, batch files and operator manuals to maintain and operate such programs.

A671-2.28.2.4 *Password Protection:*

a) A password protection system shall limit the ability of unauthorized individuals to access and modify certain functions of the controller. This password system shall, as a minimum, restrict access control to the controller via entry through the keypad and through the use of the system software. This password protection shall be a minimum of four numbers that shall be determined by the maintaining agency only. Authorized versions of the system software shall pass the embedded password through the data flow to the controller (or field master if so used). The system software shall include additional control access to timing and phasing parameters, the uploading and downloading of data, and the changing of the operational mode of the controller(on line, off line, flash).

b) The password protection system shall include the ability to limit access to various controller functions as a function of the access level assigned to the password holder. At least ten different access levels shall be provided.
c) The password protection system shall be capable of including 25 different password holders, not including the owner.
d) The "Owner" password shall be the only password with access to the password database. The "Owner" password holder shall be the only holder who can add or delete password holders and/or the holders password level.

A671-2.28.2.5 *HELP Support:*

Context-sensitive help shall be provided for all display screens in the FTU controller interface software program.

A671-3 Warranty:

The Contractor warrants that the goods sold per this specification will conform to applicable specifications, drawing, designs or descriptions; will be free from defects in material and workmanship; and, shall be fit for the particular purpose specified by the buyer/user. This warranty will remain in effect for three years from the date of installation, not to exceed 3-½ years after the date of receipt.

Under this provision, the seller and/or manufacturer agrees to replace, within a reasonable time, any parts, features, or product found to be defective during the warranty period at no cost to the maintaining agency.

SECTION A676
CONTROLLER CABINET

A676-1 Description

This section specifies the minimum requirements for the certification of traffic signal controller cabinets (NEMA and Type 170) used to house traffic controllers, controller accessories, and other traffic control devices.

The state standard for all traffic signal controller cabinets shall include a generator panel. At a minimum, the generator panel shall consist of a manual transfer switch or an automatic transfer switch, where required, and a twist-lock connector for generator hookup. The transfer switch knob and twist-lock connector shall be located and labeled on a panel easily accessible behind a separate lockable door. The door shall be equipped with a tamper resistant stainless steel hinge. The door assembly shall be weatherproof and dustproof. The door shall have a movable plate to cover an opening for the generator cable. The generator panel shall be located as close as possible to the AC main circuit breaker. The generator panel shall not be located on the main cabinet doors or back doors. The connection to a generator or other external power source shall be a waterproof, secure connection. The connection shall allow authorized personnel to access, connect, and secure an external power source to the cabinet for power restoration within five minutes of arrival at the location.

Manufacturers seeking approval for their device shall provide the FDOT with a unit to be evaluated by the State Traffic Engineer in accordance with these specifications.

Documentation indicating that the furnished unit meets all requirements specified shall be provided before any evaluation is to take place.

A676-1.1 T.S. 2 - Type 1 Cabinet

The T.S. 2 Series Controller Cabinet is covered in NEMA *STANDARDS PUBLICATIONS NO. T.S. 2-2003 TRAFFIC CONTROLLER ASSEMBLIES* with the following exception: T.S. 2 Series Controller Cabinet Dimensions shall have minimum inside dimensions as listed in Table A676-1.

A676-2 NEMA General Requirements

A676-2.1 Classification of Types

Type 1, 2, and 3 cabinets shall be designed for mounting onto a concrete, wood or steel strain pole. Type 4 cabinets shall have the option of pole or base mount capability as required by specific project requirements. Type 5 controller cabinets shall be designed for mounting onto a concrete base, or other FDOT-approved equivalent base. The bottom of the cabinet shall be open.

A676-2.2 Material

Cabinets shall be constructed of 5052 sheet aluminum alloy which has a minimum thickness of 1/8 inch. All inside and outside edges of the cabinet shall be free of burrs. The outside surface of the cabinet shall have a smooth, uniform natural aluminum finish. All welds shall be neatly formed and free of cracks, blow holes and other irregularities. All welds shall be made by using the Heliarc welding method. Other welding methods may be used if approved by the FDOT. The FDOT may approve special design cabinets which use special material combinations and gauges.

A676-2.3 Identification

The manufacturer's name and Florida certification number shall appear only on the inside of the main cabinet door along with the year and month of manufacture. This information shall be attached to the door by a method which is water resistant.

A676-2.4 Documentation

Four copies of the cabinet wiring diagram shall be provided with each cabinet. The nomenclature of signal heads, vehicular movements and pedestrian movements on the wiring diagram shall be in accordance with Figure A676-1 and the signal operating plan. A heavy duty, re-sealable plastic opaque bag shall be mounted on the backside of main cabinet door for storing cabinet prints and other documentation that may be subject to damage by sunlight or moisture.

A list which identifies the terminal strip termination connections for the signal cable used for: (1) vehicular and pedestrian signal heads, (2) the detector loop lead-in cable, and (3) the pedestrian pushbutton wire shall be attached to the inside of the main cabinet door. This information shall be attached to the door by a method which is water resistant. The adhesive material shall hold up under ambient temperature ranging from -30 to +165°F (-34 to +74°C).

A676-3 Operational Requirements

A676-3.1 Flashing Operations

Unless otherwise specified in the contract documents, all major street through vehicular signal heads (numbers 2 and 6) shall flash yellow; all minor street vehicular signal heads (1, 3, 4, 5, 7, and 8) shall flash red. Overlaps shall flash per contract documents.

Pedestrian signal heads shall be dark (off) during flashing operation.

A676-3.2 Uniform Code Flash

Transfer from normal operation to flashing operation shall occur at the end of the major street red interval when the flashing operation is selected by either the flash switch in the service panel or by a time-of-day device (time switch, master clock unit, etc.). The transition from normal operation to flashing operation shall not require actuation of vehicle detectors to cycle the controller unit to the appropriate transition phase(s). Transfer from normal operation to flashing operation shall be immediate when flashing operation is selected by either the flash switch in the police panel or the conflict voltage monitor's output relay is in the de-energized state.

Transfer from flashing operation to normal operation shall cause the controller unit to revert to its start-up sequence unless the conflict voltage monitors output relay is in the de-energized state, in which case the transfer to normal operation shall be inhibited until the conflict monitor is reset.

Circular green, green arrow or flashing yellow indications shall not be terminated and followed by a steady red or flashing red indication without the display of a steady yellow clearance interval. An exception is when flash operation is selected by either the police panel switch or the conflict voltage monitor.

Transition from a circular green or green arrow indication to a flashing yellow indication may be made without a yellow clearance interval.

A676-3.3 Police Switches

The following police switches shall be provided with type 3, 4, and 5 controller cabinets. The switches shall be mounted on the police panel and identified as to their function.

AUTO-FLASH: When this switch is in the FLASH position all signal indications shall immediately transfer to the flashing mode. Also, AC power shall be removed from the load switches and stop timing shall be applied to the controller unit. When this switch is placed in the AUTO position the controller unit shall operate in accordance with the appropriate specification.

MANUAL ON-OFF: When this switch is in the on position, a logic ground shall be applied to the manual control enable input of the controller unit.

MANUAL JACK: A manual jack shall be installed on the police panel. The jack shall intermate with a three circuit, 1/4 inch diameter phone plug. The tip and ring (middle) circuits of the jack shall be connected to the logic ground and the interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground shall be connected to the interval advance input of the controller unit.

When specified in the contract documents, a manual pushbutton with cord shall be provided with Type 3, 4 and 5 cabinets. The cord shall have a minimum length of 3 feet (0.9 m). It shall have a 1/4 inch diameter, three circuit plug connected to one end and a manual pushbutton enclosed in a hand held enclosure at the other end. A complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval which is active except the vehicular yellow and all red clearance intervals. Cycling the push-button during the vehicular yellow or all red clearance intervals shall not terminate the timing of those intervals.

A676-3.4 Service Switches

The following service switches shall be provided with Type 3, 4, and 5 cabinets. The switches shall be mounted on the service panel or other locations approved by the FDOT and identified as to their functions.

SIGNALS ON-OFF: When this switch is in the off position, AC power shall be removed from all signal heads.

AUTO-FLASH: When this switch is in the FLASH position, all signal indications shall transfer to the flashing mode in accordance with the uniform code flashing requirements. Also, AC power shall be removed from the load switches when the signal indications transfer to the flashing mode. The controller unit shall operate in accordance with appropriate specifications during the flashing mode. When the switch is placed in the AUTO position transfer from the flash mode to normal operation shall be made in accordance with uniform code flash requirements.

CONTROLLER ON-OFF: When this switch is in the off position, AC power shall be removed from the controller.

AUX POWER ON-OFF: When this switch is in the off position, AC power shall be removed from all circuits of the cabinet except for the duplex receptacle, cabinet light and ventilation fan.

VEHICLE DETECTORS: A three position switch shall be provided for each phase of the controller unit. The functions of the switches are as follows:

Down position (Call):	call is placed into the controller unit.
Up position (Auto):	output of vehicle detector is connected to the controller unit vehicle detector input.
Center position (Off):	no call is placed into the controller unit.

The SIGNALS ON-OFF	Switch shall be connected to the control input of a contactor (displacement relay). Current going to the police

	panel shall not exceed five amperes (amps) total. The main signal head power buss and cabinet power shall not be directly routed through the service or police switches.
Up or center position (Auto):	preemption operation is activated by an external source.
Down position (test):	preemption operation shall cycle through the preemption intervals as long as the switch is manually held in this position. This position of switch shall be a momentary contact.

A676-4 Design Requirements

A676-4.1 Dimensions and Space

The minimum inside dimensions for Types 1, 2, 3, 4, and 5 cabinets are listed in Table A676-1.

All equipment shall be placed on the shelves of the cabinet in an upright position. Stacking equipment on top of other equipment is prohibited. A minimum clearance of six inches shall be provided between the top of the cabinet and the top of any equipment placed on the top shelf of the cabinet. A minimum clearance of two inches shall be provided between each side of the cabinet and the equipment placed on the cabinet shelves.

A676-4.2 Doors and Locks

Type 1, 2, 3, 4, and 5 cabinets shall be provided with a hinged, rain tight and dust tight main door which allows access to 80 percent or more of the cabinet front. A neoprene gasket shall be attached to the main door in accordance with Figure A676-2.

Type 3, 4, and 5 cabinets shall be provided with a hinged, rain tight and dust tight police door which allows access to the police switches and manual jack. A neoprene gasket shall be attached to the police door in accordance with Figure A676-2.

The police door shall be located in the bottom half of the main door for Types 3 and 4 pole mount cabinets. The police door shall be located in the upper half of the main door for Types 4 and 5 base mount cabinets. When using the optional Type 4 pole mount cabinet, the police door shall be located in the bottom half of the main door.

Hinges shall be made of 14-gauge stainless steel. The hinge pins shall be constructed of stainless steel material. The hinge shall be designed to prevent the door (main or police) from sagging. The hinges for the main and police doors shall be located on the right side (viewed from the front).

Type 3, 4, and 5 cabinets shall be furnished with a three point latching system for the main door. The latching system shall consist of the following latching points.

a) Center of the cabinet (lock).
b) Top of the cabinet--controlled by the door handle.
c) Bottom of the cabinet--controlled by the door handle.

Security points b and c shall remain in the locked position until the main cabinet door lock is unlocked. When the lock is unlocked, rotation of the door handle shall allow the main door to swing open.

Type 3, 4, and 5 cabinets shall be furnished with a door stop which retains the main door open in a 90-degree and 120-degree position.

A676-4.3 Police and Service Panels

A police service panel shall be provided with Type 3, 4 and 5 cabinets. The panels may be constructed of either sheet aluminum or cast aluminum. The police panel shall be located behind the police door which is attached to the main door. The police panel shall have the following minimum dimensions:

a) Height – 4 inches
b) Width – 8 inches
c) Depth – 2.5 inches

The service panel shall be mounted on the back side of the police panel.

A676-4.4 Ventilation

Type 1 and 2 cabinets shall be vented to allow dissipation of the heat generated by the equipment housed inside the cabinet.

Type 3, 4, and 5 cabinets shall have a thermostatically controlled fan located at the top of the cabinet. The exhaust fan shall have a minimum rating of 100 cubic feet per minute (0.047 m3/s). The thermostat shall be mounted on the inside top of the cabinet and shall have a minimum temperature range from 80 to 125°F (27 to 52°C). The intake vent shall be rain tight and shall be located on the bottom half of the cabinet and covered with an easily removable filter.

A676-4.5 Shelves

Type 2 cabinets shall be furnished with one shelf. Type 3, 4, and 5 cabinets shall be furnished with two adjustable shelves. Shelves shall be adjustable, in maximum of 2-inch increments from the top of the load panel to 12 inches from the top of the controller cabinet.

A676-4.6 Mounting

Type 1, 2, and 3 cabinets shall be supplied with hardware for attaching the top and bottom half of the cabinet onto a flat or round surface. Optional wall or pole mount hardware shall be provided for mounting Type 4 cabinets in specific installations.

Type 4 cabinets shall have rigid tabs attached to the bottom of the cabinet in accordance with Figure A676-3.

Type 5 cabinets shall have rigid brackets attached to the bottom of the cabinet in accordance with Figure A676-3.

Rigid brackets and tabs shall be constructed with the material used for the cabinet.

Type 4 and 5 cabinets shall be provided with one of the following alternatives for fastening it to the concrete base:

a) Galvanized anchor bolts, nuts, lock washers, and flat washers in accordance with American Society for Testing and Materials (ASTM) A 153. The anchor bolts shall be at least 1/2 inch in diameter, 7 inches in vertical length with at least 3 inch horizontal , or
b) Heavy duty machine bolt anchors, flat washers, lock washers and machine screws at least ½-inch in diameter.

A676-4.7 Ground Bussbar

Ground bussbars shall be fabricated of a copper alloy material compatible with copper wire. Ground bussbars shall have at least two positions where an #6 AWG stranded copper wire can be attached.

A ground bussbar shall be mounted on the side of the cabinet wall adjacent to the power panel for the connection of AC neutral wires and chassis ground wires.

If more than one ground bussbar is used in a cabinet, a minimum of a #10 AWG copper wire shall be used to interconnect them.

A676-4.8 Signal Operating Plans

Controller cabinets shall be wired in accordance with the signal operating plan specified in the contract documents. If phases are omitted for future use, the cabinet shall be wired for these future phases. However, the load switches for the future phases do not have to be furnished.

A676-5 Electrical Requirements

A676-5.1 Wiring

Wiring in the cabinets shall conform to the requirements of the National Electrical Code (NEC) and all of these specifications. All wiring shall be laced. All conductors in the cabinet shall be stranded copper.

All controller inputs and outputs, as specified in Section A671, shall be terminated on terminal strips. The connector harnesses for the controller, conflict monitor, vehicle detectors, and other controller accessory equipment shall be furnished and wired into the cabinet circuitry.

A vehicle detector harness shall be furnished for each vehicular movement shown in the signal operating plan. The detector harness shall be constructed in accordance with Section A660. Four terminal strip circuits shall be provided for each detector harness for connection of the loop lead-in cable.

A676-5.2 Terminal Strips

The voltage and current rating of terminal strips shall be greater than the voltage and current rating of the wire which is terminated on the terminal strip.

Conductors shall be terminated on terminal strips with insulated terminal lugs. A calibrated ratchet crimping tool shall be used to terminate the conductor in the terminal lug.

When two or more conductors are terminated on field wiring terminal strip screws, a terminal ring lug shall be used for termination of those conductors. All terminal strip circuits shall be numbered.

A676-5.3 Cabinet Light and Receptacle

Type 3, 4, and 5 cabinets shall be provided with a minimum of 20 W fluorescent lamp and a clear shatterproof shield assembly which is mounted on the inside, front top of the cabinet. The lamp shall automatically turn ON when the main cabinet door is opened and OFF when the door is closed.

A three wire 115 V AC duplex receptacle shall be mounted and wired in all cabinets. The receptacle shall be protected by a 15 A circuit breaker. The receptacle shall not be mounted on the main cabinet door or police and service switch panels.

A676-5.4 Main Circuit Breaker

Type 1 and 2 cabinets shall be provided with a 15 A circuit breaker. Type 3, 4, and 5 cabinets shall be provided with a 30 A circuit breaker.

The main circuit breaker shall turn off all power to the cabinet and shall not be used for the power switch which is located in the service panel.

A676-5.5 Radio Interference Suppression

A radio interference suppressor shall be provided in series with the AC power before it is distributed to any equipment inside the cabinet. The suppressor shall provide a minimum attenuation of 50 decibels over a frequency range of 200 kHz to 75 MHz, when used with normal installations. It shall be hermetically sealed in a metal case.

The radio interference suppressor shall have the same minimum current rating as the main circuit breaker (Section A676-5.4) and shall meet the standards of the Underwriter's Laboratories, Incorporated and the Electronic Industries Association.

The ground connection of the radio interference suppressor shall be connected only to AC neutral and shall not be connected to earth ground directly.

A676-5.6 Opto Isolation

The Opto Common input is the common reference pin for four optically isolated inputs.

The Opto inputs are intended to provide optical isolation for Pedestrian Detector and Remote Interconnect Inputs. The Opto inputs are intended to connect through external 27 kS, 1 W resistors for 120 V AC operation and are intended for direct connection to 12 V AC from the cabinet power supply for Pedestrian Detector applications. These inputs may alternatively be used for low-true DC applications when the Opto Common pin is connected to the 24 V supply.

- The Opto inputs shall provide electrical isolation of 10 MS minimum resistance and 1000 V AC RMS minimum breakdown to all connector pins except the Opto Common pin.
- These inputs shall exhibit nominal impedance to the Opto Common pin of 5 kS' ± 10 percent, and shall require 2.4 mA ± 10 percent from a nominal 12 V AC supply.
- The Opto inputs shall not recognize 3 V AC RMS or less relative to the common input
- The Opto inputs shall recognize 6 V AC RMS or more relative to the common input
- Any steady state voltage applied between an Opto input and the Opto Common shall not exceed 35 V AC RMS.
- Opto inputs shall not be acknowledged when active for 25 ms or less, and shall be acknowledged when active for 50 ms or more.

A676-5.7 Time Switch Connections For Flashing Operation

Terminal connections shall be provided for connection of a time switch as specified in Section A678 for selecting flashing operation. The terminal circuit connections for the time switch output circuits shall be connected to the cabinet circuitry during all of the following operation:

- During the time intervals that the time switch is programmed to be on, the intersection shall not flash.
- During the time intervals that the time switch is programmed to be off, the intersection shall flash.
- When a day of the week is programmed to be omitted, the intersection shall flash all day.

A label shall be placed on the inside of the main cabinet door which explains how to program the time switch to obtain the above operation.

A676-6 Load Resistors

A load resistor (or any other FDOT-approved low impedance device) shall be installed between the AC (common) and each signal field wiring terminal for the yellow, green and walk indication. All load resistors shall be on the front side of any panel used in the cabinet.

A676-7 Flashing Beacon Controller

All flasher inputs and outputs shall be terminated on a terminal strip. The flasher shall plug into a socket which is mounted on a panel. The panel shall be mounted on the back inside wall of the cabinet so that the front end of the flasher is perpendicular to the main door.

A676-8 Coordination Units

All inputs and outputs of the coordination unit, as specified herein, shall be terminated on terminal strips. The connector harness for the coordination unit shall be furnished and wired into the cabinet circuitry when coordination units are specified in the contract documents.

The flash and input circuit of the interconnect cable to the coordination unit shall be connected to the center contact of the switch. The switch shall be used to select either flashing operation or free operation of the intersection when flashing operation is called for by the master clock unit.

A676-8.1 Secondary Coordination Units

The coordination unit interconnect input circuits shall be isolated from the interconnect cable circuits by an isolation relay or circuit. The relay shall conform to the requirements of Section 678-6 (transfer relay), except, the current rating of the contact shall be 1 A or more.

A terminal strip shall be furnished for termination of the interconnect cable. Circuits shall be provided on the terminal strip for the following interconnect signals: Dial 2, Dial 3 selection, Offset 1, Offset 2 and Offset 3 selection, and flashing operation.

A676-8.2 Master Coordination Units

The coordination unit's dial selection input circuits and sync pulse output circuit shall be isolated from the interconnect cable circuits by an isolation relay or circuit. The relay shall conform to the requirements of Section A678-6 (transfer relay), except the current rating of the contact shall be 1 A or more.

A terminal strip shall be furnished for termination of the interconnect cable. Circuits shall be provided on the terminal strips for the following interconnect signals: Dial 2, Dial 3 selection, Offset 1, Offset 2 and Offset 3 selection with sync pulse superimposed on the offset circuits flashing operation.

Switches shall be furnished in the cabinet for manually selecting the following modes of operation for the interconnect system:

- Dial 1, Dial 2, or Dial 3
- Offset 1, Offset 2, or Offset 3
- Flashing
- Time-of-Day interconnected system is controlled by the master clock unit.

A676-9 Transient Protection

A676-9.1 General

Transient suppressors shall be furnished for the main AC power input, all signal head field wiring terminals, all interconnect cable terminals and all loop lead-in cable terminals which are located in the cabinet. Transient suppressors shall be on the front side of any panel used in the cabinet.

A676-9.2 Main AC Power Input

The transient suppression for the main AC power input of the cabinet shall be connected on the load side of the cabinet circuit breaker.

A676-9.3 Field Wiring Terminals

The transient suppressors for signal and interconnect cable field wiring terminals shall be designed in accordance with the following requirements:

- Clamp the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected.
- Withstand a surge current of 1000 A with an 8 x 20 μs waveform six times (at 1 second intervals between surges) without damage to the suppressor.

A676-9.4 Loop Lead-In Cable Terminals

The transient suppressors for loop lead-in cables shall be designed in accordance with the following requirements:

- Protect the detector unit loop inputs against differential (between the loop lead) surges, and against common mode (between loop leads and ground) surges.
- Clamp the surge voltage to 25 V or less when subjected to repetitive 300 A surges.
- Withstand repetitive 400 A surges with an 8 x 20 µs waveform without damage to the suppressor.

The transient suppressors shall not affect the operation of inductive vehicle loop detectors.

A676-9.5 Installation

The suppressor lead shall be kept as short as possible. Grounds shall be made directly to the cabinet wall or panel as shown in Figure A676-4. The grounded side of the suppressors may be bolted directly to the cabinet wall panel or connected to a ground bussbar which is directly bolted to the cabinet wall/panel.

Table A676-1 Cabinet Dimensions

Minimum Dimensions in Inches (millimeters)			
Cabinet Type	Height	Width	Depth
1	13 (330)	10 (254)	11 (279)
2	27 (685)	15 (381)	12 (304)
3	32 (812)	20 (508)	14 (355)
4	48 (1229)	29 (736)	16 (406)
5	54 (1371)	38 (965)	24 (609)

A676-10 General Requirements for Type 170 Traffic Controller Cabinets

A676-10.1 Purpose

This specification details the FDOT’s minimum acceptable requirements for the materials and workmanship for type 170 traffic signal control equipment to be supplied for sale or use in Florida. This specification governs hardware and functional requirements for software for the system and sub-system operation.

The equipment specified herein consists of the following:

Model 412C Program Module
Model 400 Modem
Power Distribution Assembly 2
Model 200 Load Switch
Model 204 Flasher
Model 210 Conflict Monitor (with Absence of Red Monitoring)
Model 222 Loop Detector
Model 242 DC Isolator
Model 252 AC Isolator
Model 430 Flash Transfer Relay
Model 336S (Stretch) Cabinet Only
Model 332A (Modified) Cabinet Only
Model 334 Cabinet Only
Model 552A Cabinet Only

A676-10.2 Specifications

A676-10.2.1 Related Specification and Standards

All equipment furnished shall conform to these specifications, and/or to the plans, and special provisions for the specific project. Further, equipment shall conform to the applicable requirements of the Underwriter's Laboratory Incorporated (UL); the Electronic Industries Association (EIA); the National Electric Code (NEC); the American Society for Testing and Materials (ASTM); the American National Standards Institute (ANSI); Institute Of Electrical and Electronic Engineers (IEEE), and other applicable standards and specifications.

A676-10.3 FDOT Requirements

This section specifies the FDOT’s specific requirements that extend or modify the typical Type 170 design characteristics.

A676-10.3.1 Cabinet Requirements

A676-10.3.1.1 Mounting

Cabinets shall be supplied with a removable base plate and provisions for a standard base mounting bolt pattern.A676-10.3.1.2 Police Button (Optional):

Cabinet assemblies may be specified to provide a manual police push button on a coiled rubber cord, in conjunction with a manual/auto switch. When placed in the manual position, "stop time" shall be applied to the controller, and "recall" shall be applied to all phases. Activation of the push button shall "advance" the controller. Manual advancement will be prohibited in the yellow and red timing intervals.

A676-10.3.1.2 Output File

The output file shall be fabricated using a "hard wired" harness; printed board circuit boards are not acceptable.

A676-10.3.1.3 Shelf

An aluminum shelf with storage compartment shall be provided in the rack below the controller (for remote secondary monitor/lap top computer use). The storage compartment will have telescoping drawer guides for full extension. The compartment top shall have a plastic non-slip plastic laminate attached. An RS-232 connector shall be provided for communications to the C2S port.

A676-10.3.1.4 Loads

"Greens-Peds-Yellows" shall be provided with "dummy loads" consisting of a 4.7 kSresistors rated at 5 watts minimum. The dummy loads shall be mounted on a terminal block in the rear of the output file or other approved location. One side of each dummy load shall be wired to AC return. It shall be easily jumped to the outputs from the selected load switches.

A676-10.3.1.5 Light

Each cabinet shall include at least one fluorescent lighting fixture that is mounted inside the top front portion of the cabinet. It shall be complete with a 20 watt cool white lamp, and be operated by a normal power factor UL-listed ballast. Door actuated switches shall be installed to turn on the cabinet light when either the front or rear door is opened.

A676-10.3.2 Surge Protection

A676-10.3.2.1 General

Each 336S and 332A cabinets shall be provided with devices to protect the control equipment from surges and over voltages. This shall include incoming power lines, the Input File, the Output File (load switch-packs), and communication lines. The surge protection for the Input File shall be in accordance with the assignment of the slots of a standard 336S cabinet assembly. Surge protector termination panels shall be provided, attached to the cabinet rack assembly. AC isolation terminals shall be on the same side of the cabinet as the AC service inputs. DC terminals and loop detector terminals shall be installed on the opposite side of the cabinet from the AC power lines, to reduce electromagnetic induction The surge protector panels shall be designed to allow for adequate space for a wire connection and surge protector replacement. Surge protection shall be provided for the full capacity of the cabinet Input File.

For the 332A cabinet, appropriate input surge protection shall be mounted on the lower input termination panel. For the 336S cabinet, appropriate input surge protection shall be mounted on a custom fold down termination panel at the input file.

Under no circumstance (normal operation or short-circuit condition) shall the amperage capacity of the internal wiring and printed circuit board traces be less than the protecting threshold of circuit breakers and surge protectors provided.

A676-10.3.2.2 Power Distribution Assembly

The power distribution assembly of each controller cabinet shall include a lightning/surge/transient protection unit on the AC service Input. It shall be capable of reducing the effect of lightning transient voltages applied to the AC line. The protector shall be a two stage series/parallel device. It shall have the following features and functions:

- Maximum AC line voltage: 140 V AC
- 20 pulses of peak current, each of which will rise in 8 microseconds and fall in 20 microseconds to one-half the peak: 20 000 amperes.
- The protector shall be provided with the following terminals:
  - Main line (AC Line first stage terminal)
  - Main Neutral (AC Neutral input terminals)
  - Equipment Line Out (AC Line second stage output terminal, 10 A).
  - Equipment Neutral Out (Neutral terminal to protected equipment).
  - Ground (Earth connection)
- The main AC line in and the equipment line outer terminals shall be separated by a 200 microhenry (minimum) inductor rated to handle 10 amperes AC service.
- The first stage clamp shall be between Main Line and ground terminals.
- The second stage clamp shall be between Equipment Line Out and Equipment Neutral.
- The protector for the first and second stage clamp, shall have a metal oxide varistor (MOV) or similar solid state device, rated 20 kA; and be of a completely solid stage design(i.e. no gas discharge tubes allowed).

The main neutral and equipment neutral output shall be connected together internally, and shall have an MOV (or similar solid state device, or gas discharge tubes) rated at 20 kA between main neutral and ground terminals.

Peak clamp voltage: 250V at 20 kA. Voltage measured between equipment line out and equipment neutral out terminals. Current applied between main mine and ground terminals with ground and main neutral terminals externally tied together.

Output voltage shall never exceed 280 V. The protection device shall be epoxy-encapsulated in a flame retardant material. Continuous service current: 10 A at 120 V AC RMS. The equipment line out shall provide power to the Type 170E controller and to the 24 V power supply.

A676-10.3.2.3 Inductive Loop Detector Inputs

Each inductive loop detector input channel shall be protected by an external surge protection device which shall meet or exceed the following requirements:

- It shall be a three-terminal device, two of which shall be connected across the signal inputs of the detector. The third terminal shall be connected to chassis ground to protect against common mode damage.
- It shall instantly clamp differential mode surges (induced voltage across the loop detector input terminals) via a semiconductor array. The array shall be designed to appear as a very low capacitance to the detector.
- It shall clamp common mode, surges (induced voltage between the loop leads and ground) via solid state clamping devices.
- Peak Surge Current
  Peak Surge Current (six times)

Differential Mode	400 A (8 by 20 μs)	
Common Mode	1000 A (8 by 20 μs)	
Estimated Occurrences	500 @ 200 A	
Response Time	40 ns	
Input Capacitance	35 pF typical	
Temperature	-40 to +85 °C (-40 to 185 °F)	
Mounting	M5 x 0.8 x 10 (10-32 by 3/8 inch long shank) bolt	
Clamp Voltage	@400 A Differential Mode	30 V maximum
	@1000 A Common Mode	30 V maximum

A676-10.3.2.4 Signal Load Switches (Switch-Packs)

The outputs of each switch-pack in the output file shall be provided with a MOV, which is connected from the AC positive field terminal to the chassis ground. The MOV shall be rated 150 V AC and shall be a V150LA20A (or approved equal).

A676-10.3.2.5 Communication Inputs

Each low voltage communication input shall be protected as it enters the cabinet with a surge protection unit which shall meet or exceed the following requirements:

- It shall be a dual pair (four wire) module with a printed circuit board connector, double-sided and gold-plated for reliability.
- It shall mate and be installed in a ten-circuit Buchannan connector P.N. PCBlB-10A or equivalent.
- It shall be utilized as two independent signal pairs. The data circuits shall pass through the protection in a serial fashion. It shall be a hybrid two-stage unit.
- Peak Surge Current

Peak Surge Current	10 (8 by 20 µs waveshape)
Occurrences at	2000 A > 100
Response Time	<1 ns
Voltage Clamp 3	0 V maximum
Series Resistance	>15 S per line
Temperature	-40 °C to +85 °C (-40 to 185 °F)
Primary Protector	Three element gas tube 10k 8 by 20 µs, per side.
Secondary Protector	Rugged solid state clamps 1.5 kW minimum

- The line side shall be connected to the communication field wires.
- The load side shall be connected to the C2S connector of the 170E controller.
- The ground terminal shall be connected to chassis ground.

A676-10.3.2.6 Low Voltage DC Inputs

Each DC input shall be protected by an external surge protection device that meets or exceeds the following:

- It shall be a five terminal device. Two terminals shall be connected to the line side of the low voltage pair, two terminals shall be connected to the Input File side, and the fifth terminal shall be connected to chassis ground.
- Peak Surge Current

Peak Surge Current	2 kA 8 by 20 µs Wave-shape
Occurrence at Peak Current	100 typical
Response Time	5 to 30 ns
Shock	Withstands 3 m (10 foot) drop on concrete
Voltage Clamp	30 V
Series Resistance	15 S each conductor
Temperature	-20 to +85 °C (-4 to 185 °F)

A676-10.3.2.7 Pre-Emption and 115 V AC Signaling Inputs

Each preemption or AC signaling input channel shall be protected by an external surge protection device that meets or exceeds the following requirements:

- It shall be a three terminal device.
- Peak Surge Current

Peak Surge Current	2000A (8 by 20 µs waveshape)
Occurrences at Peak Current	25 Minimum
Response Time	<200 nanoseconds
Shock withstands	3 m (10 foot) drop on concrete
Peak Surge Trip Point	< 890 V nominal
Temperature	-40 to +85 °C (-40 to 185 °F)

A676-10.4 Cabinet Types

A676-10.4.1 Model 336S (Stretch) 1168 mm by 610 mm by 559 mm (46" by 24" by 22")

The Model 336S (Stretch) basic cabinet shall be base mounted

The 336S cabinet shall incorporate input surge protection mounted on a custom fold-down termination panel at the input file.

A676-10.4.2 Model 332A (Modified) 1676 mm by 610 mm by 762 mm (66" by 24" by 30")

The Model 332A basic cabinet shall incorporate a lower input termination panel. The cabinet shall be base mounted.

The cabinet shall have an auxiliary MODEL 420 output file, and be configured for 8 veh., 4 ped., 4 overlaps. All other components/racks shall be lowered, to accommodate two Model 170E controllers, the top one being utilized as a "system master", and the lower unit being the local controller. This cabinet is also intended for intelligent transportation systems (ITS)/incident/congestion management projects.

A676-10.4.3 Model 334 1676 mm by 610 mm by 762 mm (66" by 24" by 30")

The Model 334 basic cabinet shall be base mounted.

This cabinet is a stripped-down unit, and may be used by the FDOT for future projects, such as ramp-metering, sign control, or freeway surveillance.

A676-10.4.4 Model 552A (Florida)

The Model 552A cabinet is a Model 336 assembly that has been modified with a "swing out" chassis assembly for maintenance in restrictive areas where access from the rear is not possible. These cabinets are detailed in Section 676-11 of this specification.

A676-10.5 Power Distribution Assembly 2

A676-10.5.1 Assembly

The power distribution assembly shall include over-voltage protection as described in the Section A676-10.3.

A676-10.6 Model 200 Load Switch

The Load Switch Pack shall be a Model 200 load switch that is listed on the FDOT APL.

A676-10.7 Model 204 Flasher

The flasher module shall be a Model 204 flasher that is listed on the FDOT APL.

A676-10.8 Model 210 Conflict Monitor with Absence of Red Monitoring

The conflict monitor shall be a Model 210 "PLUS" CONFLICT MONITOR with the following modified functional/operational requirements.

All integrated circuits having 14 pins or more shall be socket-mounted as described in the paragraph "Integrated Circuits".

A676-10.8.1 Absence of Red Monitoring

The conflict monitor shall be capable of monitoring for the absence of voltage on all of the inputs of a channel (defined here as red, yellow, and green). If an output is not present on at least one input of a channel at all times, the unit shall begin timing the duration of this condition. If this condition exists for less than 700 milliseconds, the unit shall not trigger. If this condition exists for more than 1000 milliseconds, the unit shall trigger as if a conflict had occurred, causing the intersection to transfer immediately into a flashing mode, and "stop-time" to be applied to the controller. A red signal shall require the presence of a minimum of 60 (±10) V AC to satisfy the requirements of a red indication. The red input signals shall be brought into the conflict monitor through an auxiliary connector on the monitor's front panel. A similar connector shall be provided on the output file, and a removable harness connecting the two shall be provided. An indicator on the front panel of the monitor shall be provided to identify the triggering of the monitor in response to the Absence of Red condition.

A676-10.8.2 Red Monitor Harness

A connector and terminal assembly designated as P20 (Hagnum P/N722120 or equivalent), for monitoring the absence of red, shall be an integral part of the output file. The connector shall terminate, and be compatible with, the cable and connector of a Type 170 conflict monitor unit (CMU), capable of monitoring the absence of red. The pin assignments of the P20 connector and terminal assembly shall be provided with the cabinet plans. The P20 connector shall be physically like the cable and connector of a Type 170 CMU to prevent the absence of red cable connector from being inserted into the P20 connector 180 degrees out of alignment. Details for programming of the unused red channels shall be subject to approval.

A676-10.8.3 Programming of Unused Red Channels

All cabinet assemblies shall be provided with a means of programming unused red channels by installing jumpers from red monitor inputs to 115 V AC. The connecting terminals for the jumpers shall be accessible and located in the same terminal block for all 16 channels to assure full compatibility of all cabinet assemblies with "210 Plus" conflict monitor units.

Fault Sequencing: The monitor shall detect fault sequencing of signals on a per channel basis (i.e. short or absence of yellow interval and/or simultaneous dual indications).

A676-10.9 Model 222 Loop Detectors Amplifiers

A676-10.9.1 Type

The loop detector amplifier unit shall be a Model 222 listed on the FDOT APL. The detector shall be two channels.

A676-10.10 Model 242 DC Isolator

The DC isolator unit shall be a Model 242.

A676-10.11 Model 252 AC Isolator

The AC isolator unit shall be a Model 252.

A676-10.12 Model 430 Flash Transfer Relay

The flash transfer relay unit shall a Model 430.

A676-11 Detailed Specifications and Drawings for the Type 552-A Controller Cabinet Assembly

This section specifies the requirements for the Model 552-A type cabinet used for housing Model 170E controller units. All cabinets may include an optional compartment, rack assembly for the controller and auxiliary equipment, interface panel, and miscellaneous wiring panel(s) to operate the intersection under computer control.

All cabinets shall be supplied as described in these specifications. Commonalty in mechanical and electrical design requirements for the various controller/cabinet combinations shall be a prime consideration in the construction of the cabinet to be supplied. Cabinet design shall incorporate a pullout and rotatable rack assembly (*See* Section A676-11.3.7).

A676-11.1 Assemblies

a) The following equipment shall be completely removable from the cabinet without removing any other equipment and using only a Slotted or Phillips screwdriver.
   1) Power Supply Assembly
   2) Power Distribution Assembly
   3) Input File
   4) Output File
   5) Controller Unit
   6) Storage Compartment
b) All fuses, circuit breakers, switches (except Police Panel/Technician Panel Switches; Fan Fuse) and indicators shall be readily visible and accessible when the cabinet front door is open.
c) All equipment and panels in the cabinet, when required shall be clearly and permanently labeled by the silk screen method.
d) Resistor-capacitor transient suppression shall be provided on all AC relay sockets (across relay coil) except for the flash transfer relay (FTR) in the output files where one suppression device may be common for all.
e) A leakage resistor, which permits a small amount of current to pass through the heavy duty coil, shall be installed across the terminals at relay sockets to overcome the residual magnetism.
f) Assembly of the file depth dimension shall include terminal blocks.
g) All assemblies and files shall allow air circulation through its top and bottom unless specifically called out otherwise.
h) The input file shall be hardwired only; no printed circuit motherboards shall be used.
i) Socket types for the following equipment shall be as listed below:

UNIT	SOCKET
1) Switch Pack	BEAU S-5412 (or approved equal)
2) Transfer Relay	BEAU S-5408 or approved equal)
3) Flasher Unit & Power Supply Module	BEAU S-5406 (or approved equal)
4) Conflict-Voltage	Monitor PCB 28/56S
5) Current Monitor	Harness #09-03-096-32-14

j) Connector sockets for the flasher unit, power supply, and switch pack modules shall be mounted with their front face 7½ inches deep from assembly or file front plane (Note: Output File Exception).
k) Guides (top and bottom) shall be provided for switch pack modules, flasher units, conflict-voltage monitor unit, watchdog time module and power supply module (bottom only). The guides shall begin 1.0 ±0.5 inches in from front panel surface and extend to within 0.5 inches from the connector socket face.

l) Assemblies and files shall be fabricated of 0.060-inch minimum thickness aluminum or stainless steel sheet. The metal surface shall be treated with clear chromate.

A676-11.2 Physical and Mechanical Requirements

In the selection of parts and materials, fulfillment of the requirements of this technical special provision shall be of prime consideration. In so doing, equipment design shall utilize the latest available techniques.

A676-11.3 Materials

a) Cabinets shall be constructed of domestic sheet aluminum alloy 5052, with a minimum thickness of 3.2 mm (0.125 inches).
b) The cabinet surface shall have a smooth finish and be free of rivet holes, visible scratches, and gouges.
c) The cabinet interior and exterior shall be painted by the powder coating method with the exception of the rods assembly which shall have a natural aluminum finish (*See* Section A676-11.6).
d) All exposed edges shall be broken, free of burrs and bit marks.
e) All welds shall be neatly formed and free of cracks, blow holes, and other irregularities. Corner and flat tack welds shall show good flow characteristics. Weld finish shall be smooth and free of residual discoloration along the edges and from black smut caused by inadequate gas shielding. All welds shall be made by the Heliarc welding method. All welding shall conform to applicable standards and procedures published by the AWS.
f) Rivets shall not be used.
g) Insofar as possible, all welds, especially those at eye level, shall be done internally. External welding shall be held to an absolute minimum.
h) All cabinets shall have neoprene sponge gaskets permanently secured on all doors to exclude dust and moisture. Cabinets shall be constructed so that water will not enter under any weather conditions.

A676-11.3.1 Mechanical Dimensions and Layout

Details of the mechanical dimensions and layout of the cabinet are shown in the following illustrations:

1) Figure 676- 1: Cabinet Front View
2) Figure 676- 2: Cabinet Interior Front View
3) Figure 676- 3: Interior View of Front Cabinet Door
4) Figure 676- 4: Interior View of Rear Cabinet Door
5) Figure 676- 5: Cabinet Side View
6) Figure 676- 6: Cross Section A-A: Cabinet with Rotated Rack Assembly

7) Figure 676- 7: Cross Section B-B: Cabinet with Police/Technician Panels (Top View)
8) Figure 676- 8: Cross Section B1-B1: Cabinet with Police/Technician Panels (Side View)
9) Figure 676- 9: Details A and B: Door Mounting Details
10) Figure 676-10: Cross Section C-C: Cabinet with Cabinet Bottom View
11) Figure 676-11: Cross Section D-D: Interior View of Right Cabinet Wall
12) Figure 676-12: Cross Section E-E: Interior Wall of Left Cabinet Wall with Rack Assembly

A676-11.3.2 Ventilation Requirements

All cabinets shall be equipped with two vent fans and two aluminum frame-mounted removable dust filters. The fans shall be mounted at the top of the cabinet; each fan shall be capable of moving a minimum of 0.047 m3/s (100 cubic feet per minute) of still air at sea level pressure of 101.3 kPa (14.7 psi). The 0.047 m3/s (100 CFM) rating shall apply to an uninstalled fan in free air.

The fans shall be rated for continuous duty and a lifetime of at least three years. The fans shall be mounted in a manner shown in the plans package. The fans shall circulate the air through the intake at the bottom of the cabinet and exhaust the air through opening at the top of the cabinet.

Each fan shall be equipped with a thermostat which shall have a minimum adjustable range between 21°C (70°F) and 52°C (125°F). The maximum operating temperature inside the cabinet shall be 74°C (165°F) for all the furnished cabinets. The thermostats shall be set to allow one fan to turn on first; if the temperature continues to rise, the second fan shall turn on.

The cabinet air filter shall be of the reusable, washable aluminum type with dimensions of 12 by 16 by 1 inch. The filter bottom shall rest in an aluminum channel and shall have a captive clamp mounted above the top edge of the filter to secure the filter in place. The filter shall be installed, positioned and, therefore, firmly held in place so that all intake air is filtered with no bypassing permitted through clearance spaces or gaps. There shall also be a separate aluminum water deflecting ventilation panel located on the inside of the cabinet door securing the filter to the door (*See* Figures 676-3 and 676-4).

Figure 676-13 is a schematic of the required vent fan operation.

A676-11.3.3 Cabinet Doors and Locks

a) All cabinets shall be provided with hinged rain-tight and dust-tight front and rear main doors.

b) The main cabinet doors shall be a NEMA-type with a neoprene gasket in the door.
c) Hinges shall be made of 14 gauge stainless steel and shall be continuous the full length of the doors.
d) Cabinet hardware (bolts, nuts, etc.) shall be made of stainless steel.
e) All cabinets shall be furnished with a three-point locking system for the main cabinet doors (*See* Figure 676-14 for details of the main door handle and locking bridge details). The three-point locking system shall consist of the following security points:
   1) Center of cabinet-lock unit operated by cabinet key and removable door handle. Two handles shall be provided per cabinet.
   2) Top of cabinet - operated by the removable handle.
   3) Bottom of the cabinet - operated by the removable door handle.
f) Security points (2) and (3) shall be designed so that they will remain in the unlocked position when the main cabinet lock(s) are unlocked.
g) All cabinets shall be furnished with a minimum of a two position door stop. (*See* Figure 676-15).
   1) The door stop must be internally mounted and secured at the bottom of the cabinet and shall hold the door open at 90 degrees and at the full open position (minimum of 120 degrees).
   2) The door stop shall be designed to lock into position and withstand the force of a 48km/h (30 mi/h) wind.
h) The main cabinet doors shall be supplied with PPB-1 Corbin locks and two sets of keys. The police door shall be equipped with a #2 Corbin lock and two sets of keys. No other locks shall be acceptable.

A676-11.3.4 Police Door and Panel

An optional NEMA-type police door may be required as specified by procurement specifications. The door location shall be as shown on the detail drawing for the 552-A cabinet. Figures 676-1, 676-3, 676-5 and 676-8 illustrate the location and details of the police door. Figure 676-16 provides additional police door details.

A676-11.3.4.1 Switches

There shall be two switches located in the optional police panel (from left to right) and they shall be as follows (*See* Figure 676-16 for the location of each switch on the panel (*See* Figure 676-18 for the schematic of the police panel switches):

a) Auto/Flash -- This toggle switch shall:
   1) Place the intersection on FLASH immediately.
   2) Maintain power to the controller and interface panel.
   3) Remove AC power from the load switches.

b) The flash circuit shall be designed such that:
   1) Flashing operation shall continue with any or all electronic units disconnected.
   2) A command signal from the computer through the interface controller adapter (auxiliary equipment) shall place the intersection on FLASH immediately.

c) Auto/Manual - This toggle switch shall allow the controller to be operated manually through all intervals, except for vehicle clearance. All vehicle clearance intervals shall be timed by the controller unit and shall not be terminated by actuation from the manual push-button switch. This circuit shall be routed through the controller adapter so that the manual advance operation is disabled when the controller is under computer control. Further, terminals shall be provided so that a jumper can easily be installed to eliminate this disabling feature.

A676-11.3.4.2 Hand Control

The cabinet shall be wired for, and shall include, a hand control to permit manual operation of the controller. This hand control shall be wired through a jack and shall be accessible via the police door. The manual push-button assembly shall consist of a manual push-button with a neoprene retractable power cord. The retractile power cord shall be SVO, two conductor Belden #8601 or approved equivalent. The retracted length shall be one foot with a practical extended length of six feet. The manual push-button shall be encased in a neoprene rubber housing with a diameter of one inch, and a minimum length of four inches long and shall be waterproof. The push-button jack shall be wired behind the police/technician panels to a two position Cinch 140B terminal strip or approved equivalent (*See* Figure 676-18).

A676-11.3.4.3 Information and Function Identification

The following switches, located in the police panel, shall be silk screened directly on the police panel:

a) Labeling of each switch per function:
   1) Auto/Flash
   2) Auto/Manual

The following pertinent information shall be silk screened on the inside of the police door:

b) Internal Clearance Timing: Notifying the police office that the yellow and all red clearance intervals are timed internally. This shall have a RED background with natural aluminum finish for the lettering and shall read as shown in Detail "A" of Figure 676-20.

A676-11.3.5 Technician Service Panel

All cabinets shall be provided with a technician service panel which is mounted on the back side of the police panel (inside the main cabinet front door), as shown in Figures 676-3 and 676-7.

A676-11.3.5.1 Switches

There shall be two switches located on the technician service panel located as shown in Figure 676-19 (*See* Figure 676-20 for the electrical schematic of these switches).

a) UCF – This toggle switch shall:
    1) Place the intersection on FLASH only after completing the requirements as specified under UCF requirements (Subsection A676-11.5.7).
    2) After meeting the UCF requirements, all power shall be removed immediately from signal load switches.
b) Signal On/Off – This toggle switch shall disconnect all power to the signal lights through the use of a contact switch (*See* Section A676-11.4.1.3,Contact Switch).

A676-11.3.5.2 Function Identification

The switches located on the technician service panel shall be clearly marked as to function, silk screened directly on the panel. No other method shall be acceptable.

A676-11.3.6 Rack Assembly

A676-11.3.6.1 General

a) The 552-A cabinet shall be provided with a pullout and rotatable rack assembly. The rack assembly shall house the 170E Controller, Input File, Output File #1, PDA #2, and a storage compartment. In addition, the Interface Panel shall be mounted on the top of the rack assembly attached to the top shelf.
b) The components, as specified, shall come arranged and mounted by the manufacturer/vendor in the order as shown in Figure 676-23. The rack assembly shall be constructed per Figures 676-6 and 676-12. Isometric and Orthographic views are shown in Figures 676-21 and 676-22.
c) The rack and slide/hinged mounting brackets shall be constructed so that when the rack assembly (fully loaded) can be pulled out with one hand with complete ease of operation including rotation of the assembly.
d) The fully loaded rack assembly, when pulled out of the cabinet at any point from its resting position (inside cabinet) to its full extension and rotation, shall not cause any member of the assembly to bend, warp or bind. Nor shall any increased friction be applied to the roller guides, extension brackets, etc. A maximum

deflection of the entire rack assembly (with all equipment installed) shall not exceed 3 mm (1/8 inch).

e) The rack assembly shall have 12 technician test switches mounted to the interface frame assembly. Technician test switches shall be of the momentary type and shall have eight vehicle and four pedestrian inputs.

f) The rack assembly shall have a spring-loaded latch mechanism to secure the rack assembly inside the cabinet while in the "rest" position.

A676-11.3.6.2 Construction

a) The rack shall be made of 25.4-mm (one-inch) square aluminum tubing with welded joints.

b) Rack assembly shall be constructed to house components designed to be installed in a standard EIA 483-mm (19-inch) rack. Clearance between the mounting rails shall be 451 mm (17 ¾ inches).

c) The front of the rack assembly shall be tapped with 10-30 threads with EIA universal spacing for 483-mm (19-inch) electrical equipment racks.

d) The rack assembly shall be attached to the left cabinet wall through combination slide/hinged mounting brackets.

e) The slide/hinged mounting brackets shall be fabricated from aluminum and/or stainless steel only.

f) The mounting brackets guides shall utilize 22-mm (7/8") stainless steel ball bearing rollers for easy pullout operation of the rack assembly.

g) The rack assembly shall be capable of rotating 210 degrees from its rest position after full extension from the cabinet.

h) Rack assembly shall have an aluminum rack stop rod 11 mm (7/16") Ø attached to the inside left cabinet wall from the left side of the rack assembly to lock the rack into final position.

A676-11.3.6.3 Storage Compartment

a) An aluminum storage compartment shall be mounted in the rack assembly as shown in Figure 676-23.

b) The storage compartment shall have telescoping drawer guides for full extension of drawer from rack assembly (*See* Figures 676-24, 676-25 and 676-26).

c) Compartment shall have a continuous front lip for opening the compartment top for storage.

d) Compartment top shall have a plastic non-slip (rough texture) plastic laminate attached.

e) An ACIA port shall be installed on the right hand side of the drawer at the front for connecting the field transportable unit to the controller. This ACIA port shall be connected to the communications port C2S of the Model 170E controller unit via the C2A harness.

A676-11.3.7 Cabinet Rails

The cabinet shall be provided with four cabinet rails for the purpose of mounting miscellaneous wiring panels and various mounting brackets which shall be spaced as shown in Figures 676-11 and 676-12. The rails shall extend the length of the cabinet right side 610 mm (24 inches) and shall start from the bottom of the cabinet. The length of the rails on the cabinet left side shall be 559 mm (22 inches) in length and shall start from the bottom of the cabinet. Rails shall be keyhole design with slots 50.8 mm (2 inches) on center with a top opening diameter of 16 mm (5/8 inch) to allow the insertion of a 5/8-inch by 1-inch carriage bolt. The rails shall be approximately 38 to 50 mm (1½ to 2 inches) wide by 13 mm (½ inch) deep. No uni-struts or other rails shall be accepted.

A676-11.3.8 Mounting Requirements

The cabinet shall have two aluminum plates welded inside for anchoring it to a concrete or composite type base as shown in cabinet detail drawing. The plates shall be aluminum alloy 5052, 100 mm (4 inches) wide by 3.2 mm (1/8 inch) thick and shall have four 25-mm (1-inch) diameter holes as shown in Figure 676-10.

A676-11.3.9 Cabinet Accessories

A676-11.3.9.1 Neoprene Plastic Pouch

A 250 by 350 mm (10 by 14-inch) durable multi-ply neoprene plastic pouch with zip lock shall be provided for the purpose of storing and retrieving documents. This pouch shall be located inside of the storage compartment.

A676-11.3.9.2 Cabinet Lifting Brackets

The cabinet shall be equipped with two removable aluminum mounting brackets. Each bracket shall be attached with 5/16-inch by 1¼-inch carriage bolts and hex nuts, grade 18-8 stainless steel (*See* Figure 676-27 for details).

Cabinets shall be delivered with the brackets attached in the upright position as shown in Figure 676-11. Each mounting bracket shall be able to support a weight load of 227 kg (500 pounds) and be fabricated from 6.3 mm (¼-inch) thick 6061-T6 extruded aluminum rectangular bar.

A676-11.3.9.3 Manufacturer I.D.

The manufacturer's name shall not appear on the outside of the cabinet, but shall appear on the inside of the cabinet front door, with the month and year of manufacturer. This shall be done by a moisture resistant label (or other method approved by the FDOT).

A676-11.4 Electrical Appurtenances

A676-11.4.1 Transient Protection

The cabinet shall be supplied with transient protection devices specified herein. Other circuits shall have transient protection devices or circuits when called for in these specifications.

A676-11.4.1.1 Main AC Power Input

The controller cabinet AC service shall be protected by a unit consisting of a series of hybrid type elements that include primary clamp, secondary clamp, and a RFI filter.

a) The surge protector shall be rated at 20 kiloamperes (minimum) and 8 by 20 microsecond wave shape. Terminals shall be as defined below:
    1) Main Line (AC line first stage terminal).
    2) Main Neutral (AC neutral input terminal).
    3) Equipment Line In (AC line second stage input terminal, 10 A).
    4) Equipment Line In (AC line second stage output terminal, 10 A).
    5) Equipment Neutral Out (neutral terminal to protected equipment).
    6) Ground (earth connection).
b) The inductor in the second state must not saturate with 10 A, 120 volts AC, continuous service current applied. The first stage clamp must be between mainline and ground terminals.
c) The second stage clamp must be between equipment line out and equipment neutral. Main neutral and equipment neutral out shall be connected together internally and shall have a gas charged tube rated at 20 kiloamperes between main neutral and ground terminals.
d) The filter circuit shall meet MIL-STD-220 loss test and spike test as listed in Figure 676-28.
e) With an input spike voltage of 700 volts (peak to peak), the maximum voltage excursion above/below sine wave at all phase angles from 0 to 180°, shall not exceed ± 30 volts.
f) Main line and equipment line terminals shall be isolated internally. The first stage clamp must be of solid state design with no holdover current allowed.
g) Peak clamp voltage shall be 250 volts at 20 kiloamperes. The unit must be encapsulated in flame retardant epoxy continuous service current of 10 A at 120 VAC RMS.

h) The protector response time shall be such that the voltage never exceeds 250 volts during surges.

A676-11.4.1.2 Field Terminal Transient Protection

The signal head output terminals shall be protected by a transient protection device or circuit to reduce the effect of transient voltages applied to the output terminal circuits. The protection device or circuit shall have the following minimum rating:

a) Recurrent peak AC voltage of 212 volts.
b) Energy rating of 20 joules.
c) Average power dissipation of 0.85 watts.
d) Peak current rating of 2 kiloamperes for pulses less than 6 microseconds.
e) Standby current less than 1 milliampere.

A typical cabinet transient protection device is shown in Figure 676-29.

A676-11.4.1.3 Contact Switch

A 60 A contact switch shall be placed in series with the load switch packs to provide for disconnection of AC+ light inputs to all switch packs during flash operation.

A676-11.4.1.4 Circuit Breaker

A 30 A circuit breaker shall be included in the cabinet as protection to control equipment and also for the purpose of providing a disconnect for the AC power.

A676-11.4.1.5 AC Receptacle

One ground fault circuit interrupter (GFI) type receptacle shall be provided. It shall be mounted in the power distribution assembly (PDA) #2. It shall be fused by a 15 ampere circuit breaker that can be reset separately from the main circuit breaker.

A676-11.4.1.6 Main Cabinet Door Light Switch

The cabinet shall have two main cabinet door light switches—one for the front and one for the rear main doors located on the door switch brackets. These switches shall control the interior light as shown in Figure 676-30. The switches shall be of the double pole single through (DPST) type. The second pole shall be wired for use in giving an indicator for "cabinet door open". This pole shall be wired to the interface panel terminal labeled "door open". Both circuits shall be wired such that either door opened will cause the respective circuits to activate.

A676-11.5 Cabinet and Various Panel Wiring

The nomenclature used to define signal heads, vehicular movements and pedestrian movements in the cabinet wiring and on wiring diagrams shall be accordance with Figure 676-31 and the Signal Operating Plan (SOP).

A676-11.5.1 Controller Subsystem Files and Panels

Printer circuit boards shall be PROHIBITED for use in any controller cabinet subsystem file or panel. These include, but are not limited to, the following:

a) Output File (Except for the "Red Monitor Program Board")
b) Field Service Panel
c) Auxiliary Filed Service Panel
d) Interface Panel
e) Input File

A676-11.5.2 Wiring

A676-11.5.2.1 General

The wiring in the cabinets shall conform to the latest applicable NEC requirements and all of these specifications as listed below:

a) All wires shall be cut to a proper length before assembly. No wire shall be doubled back to take up slack.
b) Wires shall be neatly laced into cables with nylon lacing. Cables shall be secured with nylon cable clamps, unless specified otherwise.
c) The position of cables between the components must be such that when the door is closed, it does not press against the cables or force the cables against the various components inside the controller cabinet.
d) Ground buss bars shall be fabricated of a copper alloy material compatible with copper wire. Ground buss bars shall have at least two positions where a #6 AWG stranded copper wire can be attached. One 152-mm (6-inch) ground buss bar with screw terminals shall be mounted on both bottom flanges on each side of the cabinet, for connection of AC neutral wires and chassis ground wires (total of two buss bars).
e) A flexible ground strap shall be attached between the left side ground buss bar and the left side bottom rear of the rack assembly.

A676-11.5.2.2 Terminals

Soldering of conductors to terminal lugs may be omitted, provided a calibrated ratchet type crimping tool is used. The cabinet wiring and controller equipment and terminals shall be so arranged within the cabinet that they will not conflict with the entrance, training and connection of the incoming conductors, and will be easily traceable and without entanglement.

A676-11.5.2.3 Wiring List

The wiring lists for the C1S, C2S, C11S and T-1 connector harnesses are provided in Figure 676-32.

A676-11.5.3 Field Service Panel

A676-11.5.3.1 General

The field service panel for the 552-A cabinet shall consist of terminal strips, circuit breakers, transient protection devices, load resistors, capacitors, cable tie mounts and associated wiring for making all field wiring connections. A reference drawing of the field service panel for the 552-A cabinet is provided in Figure 676-33.

A676-11.5.3.2 Requirements

a) The field service panel shall be mounted in the 552-A cabinet on the lower right exterior cabinet wall as shown in Figure 676-34.
b) All components shall be accessible from the front of the panel. No components or wires shall be mounted/attached behind the panel.
c) The panel board shall be made of aluminum with the following dimensions: Height: 610 mm (24 inches); Width: 457 mm (18 inches); Thickness: 3.2 to 4.8 mm (1/8 to 3/16 inch)

A676-11.5.3.3 Panel Wiring Configuration

The field service panel shall provide the necessary interconnecting junction points between the rack assembly and cabinet for the field service wires. The panel wiring is referenced in Figure 676-35 and provides all the necessary wiring information.

The panel is grouped for the three functions listed below:

a) Internal connections (jumpers) between terminals boards.
b) Wiring from the panel to the rack assembly.
c) Wiring from the panel to the cabinet.

A676-11.5.3.4 Field Service Panel Wiring

As specified below, the wiring harness shall have flexible wire covered by a flexible non-metallic conduit from the field service panel to the:

a) Power Distribution Assembly

b) Output File
c) Interface Panel

The harness shall be long enough to reach from the field service panel to the PDA after the rack assembly is fully extended and rotated to its maximum limit, with some degree of slack in the harness. However, the harness shall not be excessive in length to cause binding or crimping to the wires when the rack assembly is in its "rest" position inside the cabinet.

The harness shall have a metal clamp with a rubber grommet center attached to the field service panel to secure the harness to the panel for proper orientation of the harness with the rack assembly.

The panel wire size shall be the #18 AWG (minimum), except for those listed in Figure 676-36.

A676-11.5.3.5 Terminal Strips

The terminal strips for the panel shall be as listed below:

a) TBS1 - Marathon 1103 or approved equal.
b) TBS2 - Cinch 16-140B or approved equal.
c) TBS3 - Cinch 20-140B or approved equal.
d) TBS4 &TBS5 -Cinch 12-141B or approved equal.

A676-11.5.3.6 Circuit Breakers

The panels shall have a main cabinet circuit breaker rated at 30 A and a cabinet accessory circuit breaker rated at 15 A (for cabinet fans and light). Circuit breakers shall be mounted near the back cabinet door on the panel for the purpose of providing an easily accessible quick disconnect for the AC power and protection to the control equipment.

A676-11.5.3.7 Load Resistors

Load resistors shall be provided for all Walk, Green, Green Arrow, Yellow and Yellow Arrow Switch Pack outputs to keep the conflict-voltage monitor from going into "Flash" due to a failed signal lamp. Load resistors shall be 2 kS, 10 watt.

A676-11.5.3.8 Metal Oxide Varistor

MOVs shall be physically tied to one side of each terminal on TBS4 and TBS5 and shall be physically secured to a field service panel with a 6-32 screws (*See* Figure 676-33).

A676-11.5.4 Auxiliary Field Service Panel

A676-11.5.4.1 General

The auxiliary field service panel for the 552-A cabinet shall consist of, at a minimum, four terminal strips, 18 detector surge protectors and one pedestrian button isolation board assembly. A reference drawing of the auxiliary field service panel is provided in Figure 676-37 and a reference drawing for the pedestrian button isolation board is shown in Figure 676-39. The pedestrian button isolation board shall be mounted on the auxiliary field service panel as shown in Figure 676-38.

A676-11.5.4.2 Requirements

a) The auxiliary field service panel shall be mounted in the 552-A cabinet on the lower left interior cabinet wall as shown in Figure 676-34.
b) All components shall be accessible from the front of the panel. No components or wires shall be mounted/attached behind the panel.
c) The panel board shall be made of aluminum with the following dimensions: Height: 508 mm (20 inches); Width: 457 mm (18 inches); Thickness: 3.2 to 4.8 mm (1/8 to 3/16 inch)

A676-11.5.4.3 Panel Wiring

The harness shall be long enough to reach from the auxiliary field service panel to the input file (through flexible conduit) after the rack assembly is fully extended and rotated to its maximum limit, with some degree of slack in the harness. However, the wires shall not be excessive in the length to cause binding or crimping to the wires when the rack assembly is in its "rest" position inside the cabinet. The auxiliary field service panel shall be wired per Figure 676-37.

A676-11.5.4.4 Terminal Strips

The four terminal strips for the panel shall be Cinch 20-141B or approved equivalent and shall be mounted on the auxiliary field service panel.

A676-11.5.4.5 Pedestrian Button Isolation Board

A four-button pedestrian isolation board shall be installed on the auxiliary field service panel to provide for the connection of the pedestrian buttons on phases 2, 4, 6 and 8. This board shall provide electrical isolation of the field wiring to the internal cabinet wiring. The inputs to this isolation board shall be wired to terminal block TBA5 for hookup to the field terminals. The outputs of this board shall be carried through the harness to the input file to the proper wires that go to the interface extension panel of the controller.

The pedestrian button isolation board shall consist of a PC board mounted on an aluminum panel with the minimum dimensions: Height: 50 mm (2 inches); Width: 203 mm (8 inches); Thickness: 3.2 to 4.8 mm (1/8 to 3/16 inch).

A676-11.5.4.6 Surge Protectors

The 18 surge protectors shall be a three-terminal device, two of which are connected across the signal inputs of the detector for differential mode protection and the third terminal is grounded to protect against common mode damage.

A676-11.5.5 Interface Panel

A676-11.5.5.1 General

The interface panel for the 552-A cabinet shall consist of eight terminal strips; one telephone line suppressor and mounting fixture; two 24 V DC relays and mounting fixtures, and associated wiring for connecting all the required interface equipment modules. A reference drawing for the interface panel for the 552-A cabinet is provided in Figure 676-41.

A676-11.5.5.2 Requirements

a) The interface panel shall be mounted in the 552-A cabinet as shown in Figures 676-21 and 676-22.
b) All components shall be accessible from the front of the panel. No components shall be mounted behind the panel.
c) Panel Board: The panel board shall be made of aluminum with the following dimensions:
   Height: 109 mm (7½ inches)
   Width: 356 mm (14 inches)
   Thickness: 3.2 to 4.8 mm (1/8 to 3/16 inch) See Figure 676-42 for panel detail.
d) Front Cover: The front panel shall be covered by a clear plexiglass sheet 6.3 mm (¼ inch) thick. The front cover shall be supported from the panel by four 38 mm (1½ inch) separators. Locations of separators are shown on panel layout drawing. Panels shall be secured to the separators using wing nuts which shall be removable, without the use of tools, from the fixed separators.

The plexiglass cover shall have a 13-mm (½-inch) slot, centered over each of the terminal strips for easy access of test probes. All covers and panels shall be interchangeable; that is, any cover shall fit on any interface panel provided under this technical special provision. The plexiglass cover detail is shown in Figure 676-43.

A676-11.5.5.3 Panel Wiring Configuration

The panel wiring shall provide the necessary interconnecting junction points between interface equipment cable harnesses and controller/cabinet input and output signal. The panel wiring provides the functional wiring information for connecting the interface equipment in the cabinet. The wiring assignments between the interface panel and various terminal panels are listed in Figure 676-44.

The panel wiring is grouped for the functions listed below:

a) Internal connections (jumpers between terminal boards).
b) Wiring from controller and related cabinet functions to the terminal boards on the interface panel.

A676-11.5.5.4 Interface Panel Wiring Details

Panel wire size shall be #18 AWG (minimum), except for ground, rated at 1kV, 105 °C (221 °F), Type C insulation with nylon jacket meeting MIL SPEC. 16878 D.

Ground wires shall be equivalent to #14 AWG wire. All wires shall be cut to proper length before assembly. No wire shall be doubled back to take up slack. Wires shall be neatly tied into cables with nylon cable ties. Cables shall be secured with nylon cable clamps. Cables shall be placed such that they will not interfere with the placement of external cables. The internal harnesses shall be located between TB1, TB2 and TB3. The external and internal wiring would then be located outside of TB1 and TB4, between TB2 and TB3.

A676-11.5.5.5 Terminal Strips

Terminal strips shall be Cinch 140 series, barrier type or approved equivalent. The terminal strip locations are indicated on the panel layout drawing, Figure 676-41. Terminals shall have brass screws nickel/cadmium plated.

A676-11.5.5.6 Terminal Identification

All terminal board terminals and surge suppressors and their holders shall be clearly identified on the panel by the use of appropriate characters and shall be silk-screened onto the panel.

A676-11.5.5.7 Relays and Sockets

The K1P and K2F relays shall be Potter Bromfield K10P11D1524 and Sockets 27E487 with hold-down spring 20C297 or approved equivalent. The socket locations are shown on the panel layout drawing in Figure 676-41. All screws on the relay socket shall be brass with nickel/cadmium plating.

A676-11.5.6 Cabinet Completion Requirements

The 552-A cabinet shall be supplied completely wired including all internal equipment connections. The interface panel layout and panel location layout are given in Figures 676-41 and 676-22. Interconnection wiring, shown in Figure 676-44, shall be done neatly and in accordance with previous sections on wiring practices.

A676-11.5.7 Flashing Operation

A676-11.5.7.1 Uniform Code Flash (UCF)

When a non-emergency flashing operation is required, the selected operation shall be performed by the UCF format. The following shall utilize UCF format:

a) UCF Flash Switch - A switch located on the technician service panel for Traffic Signal Technicians/Engineers (*See* Section A676-11.3.5).
b) Time Base Coordination Flash - An integral part of the 170E controller unit used for pre-programmed flashing operation.
c) Time Switch - An auxiliary unit (when required) in the controller cabinet provided for pre-prom flashing operation.

When flashing operation is selected by one of the above procedures, the controller assembly shall transfer from normal operation to flashing operation only at the end of the common major street red interval, the common minor street yellow interval, or the all red interval.

Uniform code flash shall be an internal function of the controller unit, it shall not be inhibited by the hold command and no external logic shall be used to provide this function.

A676-11.5.7.2 System/Emergency Flash

In the event of an emergency when flashing operation is required, the controller assembly shall immediately place the intersection on flash. Emergency flash shall be selected by any of the procedures listed below:

a) Auto/Flash Switch - A switch located on the police panel for police or traffic signal technicians/engineers (*See* Section A676-11.3.5).
b) Conflict-Voltage Monitor - Auxiliary unit in the controller cabinet senses a conflicting indication or voltage problem (*See* Subsection A678-8.1).

When flashing operation is selected by the auto/flash switch in the police panel, the system's remote flash command or by the conflict-voltage monitor, the controller assembly shall immediately transfer to flashing operation.

A676-11.5.7.3 Return to Normal Operation

The transfer of the controller assembly from flashing operation to normal operation shall cause the controller unit to revert to its start-up sequence unless the conflict-voltage monitor has transferred the controller assembly to flashing operation. If transferred to flashing operation by the conflict-voltage monitor, the controller assembly shall remain in flashing operation until the monitor unit is reset and automatic operation can be implemented through the normal start-up sequence.

A676-11.6 Model 552-A Cabinet Finish

This section specifies the requirements for the Model 552-A cabinet finish. The entire cabinet shall have a painted finish done by the powder coat method and shall be done in accordance with the following procedures.

A676-11.6.1 Surface Preparation

A676-11.6.1.1 Cleaning

The controller cabinet (inside and outside) including all aluminum components (i.e., rack assembly, door rods and bars, panels and etc.) shall be cleaned according to ASTM B 117.

a) Cleaning by immersion in inhibited alkaline cleaner such as Fremont 767, for 2-½ minutes at a temperature of 60°C (140°F). Concentration of cleaner is approximately three percent by volume.
b) All components shall be rinsed in cold water with a constant overflow.
c) All components shall be etched in a solution such as sodium hydroxide ELDORADO ALK-205 for 2-½ to 5 minutes. Concentration is approximately 13 percent. Temperature shall be 60°C (140°F).
d) All components shall be rinsed again in cold water with a constant overflow.
e) De-smut components in a 50 percent by volume chromic acid solution such as ELDORADO D-3 by immersion for 2-½ to 5 minutes. Immersion process requires that the D-3 be dissolved in water. The strength of the D-3 mixture must be 47 to 94 milliliters per liter (6 to 12 ounces per U.S. liquid gallon).
f) Rinse components again in cold water with a constant overflow.
g) All components shall have Yellow Chromate by immersion in chromic acid mixture such as Parker + Amchem Alodine 1200. Components should remain in tank 2-½ to 5 minutes. Solution concentration 1.2 to 2.2 pH at normal temperature.
h) Rinse components a final time in cold water.

A676-11.6.1.2 Masking

Care shall be taken to prevent overspray of powder coat from one surface color to another. Standard industry practices shall be followed.

A676-11.6.2 Powder Coat

Powder coat shall be applied to the entire cabinet walls, roof and doors, both inside and out. Powder coating the cabinet shall be performed according to AAMA-2603-02 specifications.

A676-11.6.2.1 Application

a) Powder shall be applied electrostatically with TGIC polyester powder, Fuller O'Brien Coating or approved equivalent, to a thickness of 50 to 100 Fm (two to three mils).
b) All components shall be baked in an oven at 190°C (375° F) for 20 minutes.
c) Paint test shall be performed for adhesion, cure and film thickness on test panels.

A676-11.6.3 Cabinet Color

The Model 552-A Cabinet shall be painted beige, Fuller O'Brien; Paint Number: PFT-401-S6 "CAMEL" or approved equivalent.

A676-12 General Panel for Traffic Signal Controller Cabinets

All traffic signal controller cabinets shall have provisions for the connection of an external power source, such as a portable generator, through a weatherproof, water-resistant, secure interface. This feature shall allow authorized personnel to access, connect, and secure an external power source to the cabinet in order to restore power (within 5 minutes of arrival) at the controller cabinet.

Provide the controller cabinet with a transfer switch rated equal to or higher than the design load of the cabinet’s main breaker and the generator input twist-lock connector rating. Ensure that the transfer switch provides a means of switching between normal utility power and auxiliary backup generator power. Ensure that the switching time between sources is no longer than 250 milliseconds.

The transfer switch shall be permanently mounted inside the cabinet. Ensure that the transfer switch meets UL Standard 1008. Ensure that the transfer switch does not allow simultaneous active power from two sources and does not allow generator backflow into normal utility AC circuits. Ensure the manual transfer switch is a two-position switch. Label the switch positions as “Generator Power” and “Utility Power”.

Equip the transfer switch with a “Utility-on” indicator, which will illuminate when normal utility power service is available and the switch is in the “Generator Power” position. The indicator must turn off when the transfer switch is moved to the “Utility Power” position. Ensure that the Utility-on indicator is clearly visible outside the cabinet, in bright sunlight, and that the indicator’s on/off state can be visually determined from a distance of 30 feet.

To provide for automatic transition from generator power back to normal utility service after utility power is restored, an automatic transfer switch may be used instead of a manual transfer switch. Ensure that the automatic transfer switch has indicators that display the status of connected power sources and indicate which power source is actively energizing the cabinet. If a relay circuit is used to provide switching, the normally closed circuits must be connected to normal utility power. The relay shall be energized only by the generator, not by the electric utility service. When energized, the relay must break the connection to normal utility power and make connection to the generator power input. Any automatic transfer switch or relay operated switch must include a bypass switch that permits the automatic switching function to be disabled and permits manual selection of the power sources connected to the cabinet.

Include a generator connection panel consisting of the manual transfer switch, or an automatic transfer switch where required, and a three-prong, minimum 30-amp twist-lock connector for generator hookup. Locate and label the transfer switch and twist-lock connector on a panel easily accessible behind a lockable exterior door. Ensure that this access door is labeled as “Generator Access Door”, equipped with a tamper-resistant hinge, and that the door assembly is weatherproof and dustproof. The access door shall be provided with a #2 lock unless otherwise specified in the plans. Provide the access door with a weatherproof opening for the generator cable. The generator hookup compartment itself shall be recessed into the cabinet and be deep enough to allow closing and locking of the access door when the generator cable is connected. Limit the generator hookup compartment and access panel’s intrusion into the cabinet interior to no more than six inches. Avoid blocking access to any other equipment in the cabinet. Locate the generator access panel as close as possible to the main AC circuit breaker. Ensure that the bottom of the access panel is no less than 24 inches above the bottom of the cabinet. Never locate the generator access panel on the main cabinet door or back door.

Connect wiring from the cabinet AC+ Input Terminal to the transfer switch. Connect the alternate power source’s wiring on the transfer switch to a receptacle that can accept a 120 VAC generator cord. Install a power service wire between the transfer switch and the existing power distribution panel in the cabinet.

If an automatic transfer switch is used it should not transfer as soon as utility power is restored. A delay should be used to make sure the utility power is stable before transferring.

A676-13 Traffic Signal Uninterruptible Power Supply System

The traffic signal uninterruptible power supply (UPS) system shall be a UPS system with battery backup functionality designed for traffic signal applications. The standard UPS shall be a line interactive type. Dual conversion UPS can be used when field conditions require additional filtering of power. The UPS shall be furnished consisting of all new parts as described in this specification. All parts shall be environmentally hardened and capable of providing 800 watts of continuous power between the temperatures of -340°C to +740°C. The UPS shall be listed on the FDOT's APL.

A676-13.1 General Requirements (Standard & Dual Conversion UPS)

A676-13.1.1 Operation

A676-13.1.1.1

Up to the maximum load rating, the UPS shall be capable of supplying power to any combination of signal heads, and other equipment used at a typical traffic signal intersection.

A676-13.1.1.2

Transfer from utility power to battery power, and vice versa, shall not interfere with the normal operation of the traffic controller, conflict monitor or any other peripheral devices within the traffic controller assembly.

A676-13.1.1.3

Upon loss of utility power, the UPS shall utilize battery power in support of the system. In addition, the UPS shall be able to be operated in hot standby mode with power transfer being accomplished in 65 msec or less. In the event of UPS failure or battery depletion, ensure traffic control system will be re-powered automatically upon restoration of utility power.

A676-13.1.1.4

The removal and replacement of the UPS shall not disrupt the operation of the traffic control system.

A676-13.1.1.5

Provide a minimum of one serial data port (Dsub9 RS 232) and one Ethernet port (RJ45) for local control using a laptop PC. Ensure that these ports also allow remote control from PCs connected serially via modem connection and via an Ethernet network. The UPS manufacturer must provide configuration software designed for use with Windows XP that allows local and remote configuration of the UPS. Provide six modular, programmable (user selectable) connectors for additional alarm functions.

Windows-based configuration software shall be provided for use with the laptop PC. Alarm output functions shall be user selectable.

A676-13.1.1.6

Include a three-stage (bulk, equalize and float) temperature compensated battery charger.

A676-13.1.1.7

Regulate frequency to no more than 0.4 Hz +/- from 60 Hz while inverter is supplying power to the load.

A676-13.1.1.8

Allow on-site programming of any configurable parameter, feature, or function without the need for an auxiliary computer or other input device.

A676-13.1.1.9

Provide front panel display and control, via menu, of all operating parameters (add to 2.1.8).

A676-13.1.1.10

All harnesses necessary to operate the system shall be included and shall be quick-connect circular connectors.

A676-13.1.1.11

Front panel display shall provide visual indications for: 1) power on; 2) mode of operation (utility power or inverter); 3) alarm status; 4) battery status; 5) load levels; 6) AC output voltage; and, 7) battery test.

A676-13.1.1.12

The UPS shall operate with 85 – 154 VAC input voltage, buck and boost mode, without requiring assistance from the batteries.

A676-13.1.1.13

The UPS shall have a user selectable line qualification time between 3 and 50 seconds.

A676-13.1.1.14

If dual conversion UPS is used, it shall be on at all times and capable of producing simultaneously fully regenerated and regulated, conditioned and true on-line sine wave power with continuous and hot standby AC output capability and have a minimum operating efficiency of 90 percent.

A676-13.2 Maintenance Bypass Module

A676-13.2.1

A maintenance bypass module shall be included to safely insert power into the UPS system and shall contain a terminal strip for input and output power connection in addition to neutral and ground connections, and one 20 amp GFI technician outlet.

A676-13.3 Battery Backup System

A676-13.3.1

The battery backup system shall provide a minimum of 6.5 hours of continuous runtime for operation of the intersection (400 watts draw @ 120VAC) when normal utility power is not available

A676-13.3.2

The battery system shall be supplied with a minimum six-foot, keyed interconnect wiring harness that connects battery pack to UPS module.

A676-13.3.3

Alarm function monitoring through the UPS shall be through standard dry contact closures or the specified Ethernet communications port. Alarms shall include: 1) Loss of Utility Power; 2) Inverter Failure; 3) Low Battery; 4) Battery Temperature; and, 5) Inverter Active with Utility Fail Indication.

A676-13.3.4

Battery terminals shall have protective covering on them to prevent accidental spark or shorting.

A676-13.3.5

Include a full battery management system that includes active or equalized balancing as well as temperature, voltage, and amperage of charge or discharge monitoring to maximize the life of the batteries.

A676-13.3.6

Batteries shall be sealed and require no maintenance, cause no corrosion, and be capable of maintaining 80 percent of original capacity and performance for a minimum of five years.

A676-13.4 Cabinet

A676-13.4.1

Bare cabinet shall be NEMA 3R rated and meet requirements of Sections A676-2.2 Material and A676-2.3 Identification.

A676-13.4.2

The cabinet shall be able to be mounted to the side of a traffic cabinet or base mounted.

A676-13.4.3

Provide documentation that the UPS cabinet has been designed and tested to ensure the highest level of reliability. Fan shall be rated for a service life of three years. Door shall include air intake. Exhaust air shall be vented through top of cabinet.

A676-13.4.4

All cabinets shall be supplied with two Corbin # 2 locks with two keys each, one installed for the main door and the other for access to the generator panel door.

A676-13.4.5

The cabinet shall include, at minimum, a doorstop that will secure the door in the 90 degree open position and 120 degree open position.

A676-13.4.6

All cabinets shall include waterproof, washable filters installed in the filtered intake on the door.

A676-13.4.7

Cabinets shall be fitted with over voltage and surge / lightning protection devices as required in Section A676 to protect the installed equipment from damaging voltages. Install one IEEE Category B surge protection device in front of the UPS unit (between the input utility power and the UPS).

A676-13.4.8

All cabinets shall include one fluorescent (or LED) cabinet light with door switches on the door. The fixtures shall be mounted inside the top portion in the front of the cabinet. The door-activated switch shall control the light. Lamps shall be protected by a sturdy clear lamp shield that prevents accidental breakage. Lamps must sufficiently illuminate the cabinet. A circuit breaker protected 20 amps, 120 volt; 60 hertz GFI receptacle shall be installed in the cabinet after the surge protection device and before the UPS and, thus, shall not be limited by or regulated by the output power of the UPS unit.

A676-13.4.9

Include one 20 AMP input beaker and one 20 AMP breaker for the technician GFCI outlet.

A676-13.4.10

The housing dimensions shall not exceed 56 inches high, 26 inches wide and 24 inches deep. The side mount cabinet shall include and house all of the UPS system including batteries, harnesses, switches, surge protection device, power terminal block, and a generator hookup with transfer switch. Include shelves, mounting trays and rack rails for the batteries and UPS/PIM units.

A676-13.4.11

The enclosure shall include a built in transfer switch to bypass the UPS for maintenance and to manually transfer to generator power when a generator is connected during power outages.

A676-13.4.12

All quick disconnect cabinet connectors shall have reverse polarity proof features.

A676-13.4.13

A quick connect 30 AMP generator connector shall be built into the enclosure and accessed through a flush mount police door with a # 2 Corbin type lock. The door, when closed, shall mate with the surface of the cabinet (i.e., only the door will protrude from the cabinet surface). When the generator cable is plugged in, the door shall be capable of being secured and protected from the environment.

A676-13.4.14

Ensure all UPS system hardware (nuts, bolts, lock and flat washers), including hardware used to attach the UPS to the traffic signal controller cabinet, is stainless steel type 316 or 304.

A676-13.4.15

In each cabinet, include a product and operation manual that documents the operation and maintenance of the equipment. Cabinet wiring schematics, electrical interconnection drawing, parts layout and parts lists (including manufacturer's part numbers), shall be included within each manual. Schematics shall depict physical locations of each component.

A676-13.4.16

The Vendor shall furnish certified documentation that the cabinet is as specified and all of its applicable components have been environmentally and functionally tested and comply with this specification and referenced standard documents. The Vendor shall be responsible for furnishing documentation that shows the UPS has been fully tested and is complaint with this specification. The cabinet, batteries, and UPS shall be shipped in their own protected packaging.

A676-13.5 Back-Feed and Other Protections

A676-13.5.1

The UPS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service per UL 1778, Section 48 "Back-feed Protection Test". The upstream back-feed voltage from UPS shall be less than 1 Volts AC for the protection of the traffic engineer or technician.

A676-13.5.2

The UPS shall have lightning surge protection compliant with IEEE/ANSI C.62.41 for 2000 Volts AC.

A676-13.6 Guaranty Provisions

A warranty against defective materials, workmanship, and failure to perform in accordance with required industry performance criteria for a period of three years from date of delivery is required on all components of the UPS, including, but not limited to, batteries. If the manufacturers' warranties for the components are for longer periods, then those longer period warranties will apply. Replace any part or equipment found to be defective during the warranty period at no cost to the FDOT within ten calendar days of notification by the Engineer. Ensure that the manufacturer's warranty is fully transferable from the Contractor to the FDOT.

SECTION A678
TRAFFIC CONTROLLER ACCESSORIES

A678-1 Description

This section specifies the minimum requirements for the certification of the following controller accessories: conflict voltage monitors, load switches, flashers, time switch, transfer relay, power reduction unit, and master clock unit.

Controller accessories specified in this section shall be designed to operate in the environment requirements specified in Section A615.

Manufacturers seeking approval for their device shall provide the FDOT with a unit to be evaluated by the State Traffic Engineer in accordance with these specifications.

Documentation indicating that the furnished unit meets all specified requirements shall be provided before any evaluation is to take place.

A678-2 Conflict Voltage Monitor

A678-2.1 Classification of Types

Signal conflict voltage monitors shall be of solid state design, interchangeable with the same type of units of different manufacture. A conflict voltage (CV) monitor shall be provided and wired into the cabinet with any type of controller assembly utilizing solid state load switches for controlling the signal head indicators. CV monitors are defined as Type 3, 6, 12, and 18.

Type 3 CV monitors are three-channel units with four inputs per channel. These three channels are preprogrammed for mutual noncompatibility.

Type 6 CV monitors are six-channel units with four inputs per channel. These six channels are fully programmable for the specific application.

Type 12 CV monitors are 12-channel units with four inputs per channel. These 12 channels are fully programmable for the specific application.

Type 18 CV monitors are 18-channel units with four inputs per channel. These channels are fully programmable for the specific application.

A678-2.2 Assignment of Types

Type 3 or 6 CV monitors shall be used with two phase controller assemblies.

Type 12 or 18 CV monitors shall be used with three through eight phase controller assemblies, and all expansible controller assemblies.

A678-2.3 Operational Requirements Conflict Detection

The signal monitor portion of the CV monitor shall monitor for conflicting indications at the field connection terminals in the controller assembly. For purpose of conflict determination, a signal on any of the green, yellow or walk inputs associated with a channel shall be considered as that channel being in service.

Conflicting vehicular green and/or yellow indications and/or pedestrian walk indications present at the input channels of the CV monitor shall be detected by the CV monitor. When a conflict is detected by the CV monitor, it shall cause the contacts on the OUTPUT RELAY within the CV monitor to transfer to the conflict state. These contacts shall remain in this state until the unit is reset by the activation of the front panel control or the activation of the RESET input. Electrical power interruption following the detection of a conflict by the CV monitor shall not cause the CV monitor to reset.

Burned out signal lamps for yellow, green, and walk indications shall not be interpreted as a conflict by the CV monitor.

When the CV monitor detects a conflict, AC power to the load switches shall be removed, the controller assembly shall transfer the signals to flashing operation, and a logic low shall be applied to the stop timing input(s) of the controller unit.

Minimum Yellow Change/Red Clearance Interval Monitoring:

Yellow Plus Red Interval:

The CV monitor shall verify that the Yellow Change plus Red Clearance interval between the end of an active Green signal and the beginning of the next conflicting Green signal is at least 2.9 ± 0.1 seconds.

When the minimum Yellow Change plus Red Clearance interval is not satisfied, the CV monitor shall transfer the output relay contacts to the fault condition.

Yellow Change Interval:

The CV monitor shall verify that the Yellow Change interval is at least 2.9 ± 0.1 seconds. The Yellow Change interval consists of the duration of time in which the yellow field terminal input is active. When the minimum Yellow Change interval is not satisfied, the CV monitor shall transfer the Output relay contacts to the fault condition. A programming means shall be provided on the programming card to disable Minimum Yellow Change interval monitoring on a per channel basis.

Minimum Yellow Change/Red Clearance Interval monitoring shall be disabled when the Red Enable input is not active.

When the CV monitor transfers the Output relay contacts to the fault condition it shall cause continuity between the open and common contacts of the Output relay. These contacts shall remain in this fault condition until the unit is reset by the activation of a front panel control or the activation of the Reset input. A Conflict Monitor Power Failure shall not reset the CV monitor when it has been triggered by detection of fault prior to the conflict monitor power failure.

A678-2.4 Load Switch Failure Detection

The CV monitor shall verify that one or more combinations of signals are not simultaneously active on the same channel. The different combinations shall be **Walk & Yellow, Walk & Red, Green & Yellow, Green & Red, and Yellow & Red**.

When a combination of signals is simultaneously active on the same channel, the CV monitor shall transfer the output relay contacts to the fault condition. A programming means shall be provided to enable this function on any or all channels.

A678-2.5 Voltage Detection

The CV monitor shall include an input for monitoring the controller voltage monitor output of the controller unit. Absence of the true (logic low) state on this input shall cause the contacts of the OUTPUT RELAY of the CV monitor to transfer to the conflict state. When the controller unit does not have a controller voltage monitor output, this input to the CV monitor may be held in a true (logic low) state by connecting it to the logic ground terminal strip of the cabinet.

The CV monitor shall include two + 24 V monitor inputs for two separate + 24 V direct-current sources. Absence of the proper voltage level at any of the inputs shall cause the contacts on the OUTPUT RELAY to transfer to the conflict state. Restoration of all proper voltage levels shall reset the voltage monitoring portion of the CV monitor.

A voltage greater than + 22 V applied to both of the + 24 V MONITOR inputs shall be recognized by the unit as adequate for proper operation of the controller assembly.

If only one + 24 V direct-current supply is monitored, the two + 24 V MONITOR inputs shall be jumpered and connected to the one + 24 V direct-current supply.

A voltage less than + 18 V direct-current applied to either of the + 24 V MONITOR inputs shall be recognized by the CV monitor as inadequate for proper operation of the controller assembly. This shall cause the contacts on the OUTPUT relay to transfer to the conflict state.

Over the voltage range of 0 to + 30 volts direct-current the maximum current "in" or "out" of the + 24 V MONITOR input terminals shall be less than 10 mA. The input impedance to these terminals shall not exceed 11 kS to 0 V direct- current (Logic Ground); and surge impedance shall not be less than 100 S.

Application of a true (logic low) state to the + 24 V inhibit input shall inhibit the operation of the two + 24 V MONITOR Inputs.

A678-2.6 Absence of Red Detection:

The CV monitor shall detect the absence of any required RED signal voltage at the field connection terminals in the controller assembly. For this purpose a signal on any of the green, yellow, walk, or red indication associated with a channel shall be considered as that channel being in service.

If a load switch output is not present on at least one input of a channel at all times, the monitor shall begin timing the duration of this condition. If this condition exists for less than 700 ms, it shall not be detected as a conflict by the CV monitor. If the condition exists for one second or more, it shall be detected as a conflict by the CV monitor. If this condition exists for more than 700 ms, it may or may not be detected as a conflict by the CV monitor.

When the CV monitor detects a conflict, it shall cause the OUTPUT RELAY contacts to transfer to the conflict state. These contacts shall remain in this state until the monitor is reset by the activation of the front panel control or the activation of the RESET input. Electrical power interruption following the detection of absence of RED shall not cause the CV monitor to reset.

A678-2.7 Minimum Flash Interval

The CV monitor shall include a means of monitoring the absence of AC+ input to the unit. When the duration of power interruption exceeds 475 ± 25 ms, the unit shall transfer the contacts of the OUTPUT RELAY to the conflict state. The conflict state of the OUTPUT relay (relay coil de-energized) shall be maintained for a timed interval following restoration of power to the AC + input. The duration of this interval shall be adjustable between the minimum limits of 4 and 10 seconds with repeatability of one second and with a maximum incremental adjustment of one second. Upon completion of the timing of the minimum flash interval, the controller shall respond in its start-up mode.

A678-2.8 Start-Delay Relay

The CV monitor shall include a means of sensing the absence of AC + input to the unit. Upon restoration of electrical power following an interruption which exceeded 475 ± 25 ms, a START-DELAY relay shall cause continuity to occur between the common and open contacts of the relay for a period of 2.5 ± seconds. Following this 2.5 ± second period of time, the START-DELAY relay shall cause continuity to occur between the common and closed contacts of the relay.

The START-DELAY relay shall consist of a Form C relay output contact. These relay contacts shall switch all loads in the range from 2 mA at 18 V direct current to 3 A at 135 V alternating current.

Output Relay:

The OUTPUT RELAY of the CV monitor shall be normally energized. When the monitor's power supply fails (i.e., blown fuse, etc.) or the OUTPUT RELAY coil opens, the relay contacts will transfer to the conflict state (relay coil de-energized).

The OUTPUT RELAY shall have two sets of isolated Form C contacts. These relay contacts shall switch all loads in the range from 2 mA at 18 V DC to 3 A at 135 V AC The open circuit of the OUTPUT RELAY shall be the circuits which are open when the unit is in the no conflict (reset) state.

Reset:

Activation of the RESET pushbutton or the RESET input shall cause the OUTPUT RELAY contacts to transfer to the reset condition for the duration of either of these inputs. Removal of both of these inputs shall leave the unit in the reset condition only if there are no signal conflicts, no red monitoring failure, and no voltage monitoring failures.

A678-2.9 Design Requirements

Input Conflict Voltage:

The CV monitor shall detect full-wave and half-wave (positive and negative) conflicting voltages.

The CV monitor shall monitor the output voltages of the load switches at the field wiring terminals in the controller cabinet.

The CV monitor shall not detect a conflict until the conflict voltage reaches 15 V AC RMS.

The CV monitor shall not detect a conflict voltage which endures less than 200 mA.

The CV monitor shall detect a conflict when the conflict voltage is 25 V AC RMS or greater, for a duration of 450 ms or more.

The CV monitor may or may not detect a conflict when the conflicting voltage and time duration are within the following limits:

- Voltage: Equal to or greater than 15 V AC RMS
- Time: Equal to or greater than 200 ms, less than 450 ms
- Voltage: Greater than 15 V AC RMS, less than 25 V AC RMS
- Time: Equal to or greater than 450 ms.

Channel Inputs:

Four inputs shall be provided for each channel to permit the monitoring of voltages at vehicle GREEN, YELLOW, and pedestrian WALK signal field terminals. The unit shall be designed so that it shall not be necessary to terminate unused GREEN and YELLOW and WALK signal sensing inputs when the impedance to AC + of each of these inputs is less than the equivalent of 1500 picofarads (pF) between the lead and AC + as measured at the input to the unit.

Circuitry:

All operating circuitry and components within the CV monitor shall be readily accessible for maintenance. The CV monitor shall be of solid state design except for the OUTPUT, START-DELAY and LATCH relays.

Printed Circuit Boards:

All printed circuit boards shall be made from NEMA (FR-4) glass-epoxy or equivalent. Circuit boards exceeding 2 inches (51 mm) in any dimension shall have a nominal thickness of at least 1/16 inch (1.58 mm). Circuit boards not exceeding 2 inches (51 mm) in any dimension shall have a nominal thickness of at least 1/32 (0.79 mm).

The walls of all plated through holes shall have a minimum copper plating thickness of 0.001 inches (25 µm). All circuit tracks shall have a conductivity equivalent of at least two ounces per square foot (610 g/m2) of copper. All electrical mating surfaces shall be made of non-corrosive material.

The unit shall be designed so that each component is identified by a circuit reference symbol. This identification may be affixed to the printed circuit board(s), the cover of the unit or in an assembly drawing provided with the unit.

Dimensions:

The overall dimensions of the conflict monitor, including mating connector and harness, shall not exceed the following:

Dimensions in inches (millimeters)			
Type Monitor	Width	Height	Depth
3	4.5 (114)	7 (178)	11 (279)
6	4.5 (114)	10.5 (267)	11 (279)
12	6 (152)	10.5 (267)	11 (279)

Power Inputs:

The CV monitor shall have the following inputs for the application of power:

AC + (Line Side) Input II: The fused side of 120 VAC, 60 Hz power source. This input shall be employed to generate the voltage required to operate the monitoring logic. This input shall be jumpered internally to AC+ Input I.

AC - (Common): The unfused and unswitched return side of 120 V AC, 60 Hz power source taken from the neutral (ground) output of AC power source. This input shall be the reference signal for all traffic signal voltage sensing inputs. This input shall not be connected to LOGIC GROUND or CHASSIS GROUND within the unit.

Chassis Ground: The CV monitor shall have an input terminal providing an independent connection to the chassis of the unit.

Logic Ground: A voltage reference point and current return for the RESET input, +24 V Monitor I input, +24 V Monitor II input, and +24 V MONITOR INHIBIT input, logic circuits. This termination shall not be connected to either the AC - (common) or CHASSIS GROUND within the unit.

Cabinet Interlock:

The CV monitor shall have two terminals internally connected (20AWG jumper) to indicate the presence of the monitor to the external circuitry. These terminals shall be identified as Cabinet Interlock A and Cabinet Interlock B. If the CV monitor is disconnected from the cabinet wiring, the controller assembly shall transfer the signals to flashing operation.

Absence of Red Detection:

The Red signal input per channel shall require the presence of 60 ± 10 V AC at the field terminal in the controller cabinet to satisfy the requirements of a Red signal indication. All unused Red signal inputs shall be terminated to AC +.

Presence of AC + at the Red signal enable input shall enable the CV monitor to detect the absence of Red indication. Absence of AC + inhibits the detection of the absence of Red indication.

Logic Levels:

The RESET, +24 V MONITOR INHIBIT, and CONTROLLER VOLTAGE MONITOR inputs of the CV monitor shall conform to the logic voltage and current level provisions of Section A671.

Front Panel Controls:

The CV monitor shall have, as a minimum, the following devices mounted on the front panel and labeled as to their function:

- Pushbutton for manually resetting the CV monitor subject to the constraints of these specifications.
- Overcurrent protection device for the 120 V AC input.
- Indicator lamp that is illuminated when the CV monitor is triggered by the conflict or absence of voltage (red) portion of the unit.
- Indicator lamp that is illuminated when the CV monitor is triggered by the +24 V DC voltage or controller voltage monitor portion of the unit.
- Indicator lamps for each channel of the CV monitor which are illuminated to (1) indicate status of channels during normal operation and (2) indicate which channels were active at the time of the CV monitor triggered (this state must be latched until the CV monitor is reset).

Program Card:

Type 6, 12 and 18 CV monitors shall require a programming action to provide compatibility between channels. Programming shall be accomplished by the use of an interchangeable programming card. Details of the programming card may be obtained from the State Traffic Engineering and Operations Office in Tallahassee, Florida.

The programming card is a printed circuit board which is programmed for compatibility between channels through the use of soldered wire jumpers.

A678-2.10 Input-Output Requirements

Connectors:

All inputs and outputs, including power, shall enter the unit through a front panel connector. The connector shall conform to the provision of Military Specification MIL-C-26482.

The chassis connector for Type 3 CV monitors shall mate with an MS3116 20-41S connector.

The chassis connector for Type 6 CV monitors shall mate with an MS3116 22-55SY connector.

The A chassis connector for Type 12 CV monitors shall mate with an MS3316 22-55SZ connector and the B chassis connector shall mate with an MS3116 16-26S connector.

The A chassis connector for Type 18 CV monitors shall mate with an MS3116 24-61SZ and the B chassis connector shall mate with an MS3116 20-41SW.

Pin Assignments:

The chassis connector for Type 3 CV monitors shall have the following pin assignments:

Pin	Function	Pin	Function
A	AC + I (Jumped Internally AC - II)	X	AC
		Y	Cabinet Interlock A
B	AC + II Input	Z	Output Relay 1 Closed
C	Output Relay 1 Common	a	Output Relay 2 Open
D	Output Relay 1 Open	b	Start-delay Relay Closed
E	Output Relay 2 Common	c	Channel 3 Walk
F	Output Relay 2 Closed	d	Channel 3 Red
G	Start-delay Relay Common	e	Channel 2 Walk
H	Start-delay Relay Open	f	Channel 2 Red
J	Channel 3 Green	g	Channel 1 Red
K	Channel 3 Yellow	h	Reset
L	Channel 2 Green	i	Red Enable
M	Channel 2 Yellow	j	+24 V Monitor Inhibit
N	Channel 1 Green	k	Spare 1
P	Channel 1 Yellow	m	Cabinet Interlock B
R	Channel 1 Walk	n	Spare 2
S	+24 V Monitor II	p	Spare 3
T	Controller Voltage Monitor	q	Spare 4
U	+24 V Monitor I	r	Spare 5
V	Logic Ground	s	Spare 6
W	Chassis Ground	t	Spare 7

The chassis connector for Type 6 CV monitors shall have the following pin assignments:

Pin	Function	Pin	Function
A	AC + I (Jumped Internally to AC + II)	e	Channel 4 Yellow
		f	Channel 3 Yellow
B	AC + II Input	g	Channel 3 Red
C	Output Relay 1 Open	h	Channel 2 Yellow
D	Output Relay 2 Closed	I	Channel 1 Yellow
E	Start-delay Relay Open	j	Channel 1 Red
F	Channel 6 Green	k	+ 24 V Monitor II
G	Channel 6 Red	m	Controller Voltage Monitor
H	Channel 5 Green	n	+24 V Monitor Inhibit
J	Channel 4 Green	p	Cabinet Interlock A
K	Channel 4 Red	q	Spare 1
L	Channel 3 Green	r	Output Relay I Closed
M	Channel 2 Green	s	Start-delay Relay Closed
N	Channel 2 Red	t	Channel 6 Walk
P	Channel 1 Green	u	Channel 5 Walk
R	Red Enable	v	Channel 4 Walk
S	+24 V Monitor I	w	Channel 3 Walk
T	Logic Ground	x	Channel 2 Walk
U	Chassis Ground	y	Channel 1 Walk
V	AC -	z	Reset
W	Cabinet Interlock B	AA	Spare 2
X	Output Relay 1 Common	BB	Spare 3
Y	Output Relay 2 Common	CC	Spare 4
Z	Output Relay 2 Open	DD	Spare 5
a	Start-delay Relay Common	EE	Spare 6
b	Channel 6 Yellow	FF	Spare 7
c	Channel 5 Yellow	GG	Spare 8
d	Channel 5 Red	HH	Spare 9

The chassis connectors for Type 12 CV monitors shall have the following pin assignments:

*A CONNECTOR

Pin	Function	Pin	Function
A	AC + I (Jumped Internally to AC + II)	e	Channel 7 Yellow
		f	Channel 6 Yellow
B	Output Relay 1 Open	g	Channel 5 Yellow
C	Output Relay 2 Closed	h	Channel 3 Yellow
D	Channel 12 Green	I	Channel 3 Walk
E	Channel 11 Green	j	Channel 2 Yellow
F	Channel 10 Green	k	Channel 1 Yellow

G	Channel 9 Green	m	Controller Voltage Monitor
H	Channel 8 Green	n	+24 V Monitor Inhibit
J	Channel 7 Green	p	Output Relay 1 Closed
K	Channel 6 Green	q	Output Relay 2 Open
L	Channel 5 Green	r	Channel 12 Walk
M	Channel 4 Green	s	Channel 11 Walk
N	Channel 3 Green	t	Channel 9 Walk
P	Channel 2 Green	u	Channel 8 Walk
R	Channel 1 Green	v	Channel 7 Walk
S	+24 V Monitor I	w	Channel 5 Walk
T	Logic Ground	x	Channel 4 Yellow
U	Chassis Ground	y	Channel 2 Walk
V	AC -	z	Channel 1 Walk
W	Output Relay 1 Common	AA	Spare 1
X	Output Relay 2 Common	BB	Reset
Y	Channel 12 Yellow	CC	Cabinet Interlock A
Z	Channel 11 Yellow	DD	Cabinet Interlock B
a	Channel 10 Walk	EE	Channel 6 Walk
b	Channel 10 Yellow	FF	Channel 4 Walk
c	Channel 9 Yellow	GG	Spare 2
d	Channel 8 Yellow	HH	Spare 3

*B CONNECTOR

Pin	Function	Pin	Function
A	AC + II Input	P	Spare 1
B	Start-delay Relay Common	R	+24 V Monitor II
C	Start-delay Relay Open	S	Spare 2
D	Channel 12 Red	T	Spare 3
E	Channel 11 Red	U	Start-delay Relay Closed
F	Channel 9 Red	V	Channel 10 Red
G	Channel 8 Red	W	Spare 4
H	Channel 7 Red	X	Spare 5
J	Channel 6 Red	Y	Spare 6
K	Channel 5 Red	Z	Channel 3 Red
L	Channel 4 Red	a	Red Enable
M	Channel 2 Red	b	Spare 7
N	Channel 1 Red	c	Spare 8

The chassis connectors for Type 18 CV monitors shall have the following pin assignments:

*A CONNECTOR

Pin	Function	Pin	Function
A	AC + Input	W	+24 V Monitor II
B	Output Relay 1 Open	X	Controller Voltage Monitor
C	Output Relay 2 Closed	Y	+24 V Monitor I
D	Start-delay Relay Open	Z	Logic Ground
E	Channel 8 Green	a	Chassis Ground
F	Channel 8 Yellow	b	AC -
G	Channel 7 Green	c	Output Relay 1 Common
H	Channel 6 Green	d	Output Relay 2 Common
J	Channel 6 Yellow	e	Start-delay Relay Common
K	Channel 5 Green	f	Channel 8 Walk
L	Channel 5 Yellow	g	Channel 7 Walk
M	Channel 4 Green	h	Channel 7 Yellow
N	Channel 4 Yellow	i	Channel 6 Walk
P	Channel 3 Green	j	Channel 5 Walk
R	Channel 3 Yellow	k	Channel 4 Red
S	Channel 2 Green	m	Channel 4 Walk
T	Channel 2 Yellow	n	Channel 3 Walk
U	Channel 1 Green	p	Channel 2 Walk
V	Reset		

*B CONNECTOR

Pin		Function	
A	Channel 18 Green	Y	Channel 17 Walk
B	Channel 18 Yellow	Z	Channel 16 Walk
C	Channel 17 Green	a	Channel 16 Walk
D	Channel 17 Yellow	b	Channel 15 Walk
E	Channel 16 Green	c	Channel 14 Walk
F	Channel 16 Yellow	d	Channel 13 Walk
G	Channel 15 Green	e	Channel 13 Red
H	Channel 15 Yellow	f	Channel 12 Walk
J	Channel 14 Green	g	Channel 11 Walk
K	Channel 14 Yellow	h	Channel 10 Walk
L	Channel 13 Green	i	Channel 10 Red
M	Channel 13 Yellow	j	Channel 9 Walk
N	Channel 12 Green	k	Channel 18 Red
P	Channel 12 Yellow	m	Channel 17 Red
R	Channel 11 Green	n	Channel 15 Red
S	Channel 11 Yellow	p	Channel 14 Red
T	Channel 10 Green	q	Channel 12 Red
U	Channel 10 Yellow	r	Channel 11 Red
V	Channel 9 Green	s	Channel 9 Red

W	Channel 9 Yellow	t	Spare
X	Channel 18 Walk		

Termination:

All functions (except for spare circuits) of the I/O connectors of CV monitors shall be brought out to terminal strips located in the controller cabinet.

A678-3 Solid State Signal Load Switch

A678-3.1 General Requirements

Signal load switches shall be provided with all solid state controller assemblies for controlling power to signal indications. The signal load switch, herein referred to as a switch, shall be of solid state design with three independent switching circuits.

A678-3.2 Design Requirements Physical Characteristics:

The switch dimension shall not exceed 8.25 inches from the panel surface holding the mating connector, including any handle or gripping device. The switch shall be no more than 1.75 inches in width and no more than 4.2 inches high.

The switch shall mate with a Cinch-Jones socket S- 2412-SB or approved equivalent.

The lower surface of the switch shall not extend greater than 2.1 inches below the centerline of the connector configuration.

The switch shall be constructed so that no part of it will extend more than 0.9 inches to the left and 1.1 inches to the right of the centerline of the connect pin configuration as viewed from the front.

The switch shall be constructed so personnel inserting or removing the switch cannot be exposed to live parts and will not be required to insert their hands or fingers into a load rack.

Electrical Characteristic:

The three independent switching circuits shall be defined as circuits A, B and C. Indicator lamps for each circuit shall be provided with the switch. The A indicator shall be at the top, B in the middle, and C at the bottom when the switch is installed.

Each switching circuit shall have a minimum current rating of 10 A for a tungsten lamp or gas tubing transformer load over a voltage range of 95 to 135 V AC, RMS, at 60 Hz. No more than one circuit shall be energized at any one time unless the combined load on the energized circuits does not exceed a 10 A load. This power handling capability shall not be de-rated for operation over the temperature range specified in the Section A615.

The switch shall "turn on" within 5 degrees of the "zero voltage" point of the alternating current line sinusoid and "turn off" within 5 degrees of the "zero current" point of the alternating current load sinusoid. The voltage "turn on" shall not be required during the first "on" half-cycle of the line voltage during which the input signal is applied.

Inputs of the A, B and C circuits and the DC input of the switch shall be isolated from the line power so that line transients or switch failure will not adversely affect the controller unit. Reed relays, light coupling devices, or other approved devices may be used to isolate the input and output of each switching circuit.

Input voltage to the switching circuits shall be negative true logic, which is refers to the common of the +V DC supply and is characterized by the following:

- The transition zone of the input circuitry from the conducting to non-conducting state (and vice versa) shall occur between 6 and 16 V DC.
- A voltage between 0 and 6 V DC shall cause the output device to conduct.
- A voltage greater than 16 V DC shall cause the output device not to conduct.

Input circuits of the switch shall be returned to the +24 V DC supply in such a manner that removal of any connections to the input circuits shall allow the input voltage to rise to the +24 V DC supply.

The input driver to any of the switch's input circuits shall not be required to sink more than 10 mA.

DC voltage supply to the switch shall be 24 ±2 V. The switch shall not draw more than 10 mA times the number of circuits energized, plus 10 mA (i.e., if one circuit is energized, no more than 20 mA will be required by the switch). The current return to the 24 V DC supply is out of the switch input to logic ground via the switch driver. Output current from the switch through the load, when the switch is in the off state, shall not exceed 20 mA peak.

A678-3.3 Pin Assignment

Pin assignments of switches shall be as follows:

PIN NUMBER	FUNCTION
1	120 V AC Line Side
2	Chassis Ground
3	A Output
4	No Connection
5	B Output
6	A Input
7	C Output
8	B Input
9	+ 24 V DC
10	C Input
11	AC Common
12	No Connection

A678-4 Solid State Flasher

A678-4.1 General Requirements

A solid state flasher, herein referred to as a flasher, is used to periodically interrupt a source of alternating current line power for the purpose of providing flashing traffic signals. For the purpose of these specifications, the term solid state shall be construed to mean that the main current to the signal load is not switched by electromechanical contacts.

A Type 3 flasher is a double circuit unit rated at 15 A per circuit. The major street flashing indications shall be connected to one load circuit of the flasher and the minor street flashing indications shall be connected to the other load circuit of the flasher.

A678-4.2 Design Requirements

Physical Characteristics:

Overall dimensions of the flasher shall not exceed 8.25 inches from the panel surface holding the mating connector, including any handle or gripping device. The flasher shall be no more than 1.9 inches in width and no more than 4.2 inches high.

The flasher shall intermate with a Cinch-Jones socket type S-406-SB or equivalent. The lower surface of the flasher shall be no more than 2.1 inches below the centerline of the connector configuration.

The flasher shall be constructed so that no part of it will extend more than 0.9 inches to the left and 1.1 inches to the right of the centerline of the connector pin configuration as viewed from the front. The flasher shall be constructed so that personnel inserting or removing the flasher will not be exposed to live parts nor be require to insert either their hands or fingers into a load rack.

All printed circuit boards shall be made from NEMA (FA- 4) glass-epoxy, or equivalent (see NEMA Standards Publication for *Industrial Laminated Thermosetting Products, Publication No. LI 1-1971*).

- Circuit boards exceeding 2 inches in any dimension shall have a nominal thickness of at least 1/16 inch. Circuit boards not exceeding 2 inches in any dimension shall have a nominal thickness of at least 1/32 inch.
- The walls of all plated through holes shall have a minimum copper plating thickness of 0.001 inches (25 µm). All circuit tracks shall have a conductivity equivalent to at least two ounces per square foot (610 g/m2) of copper. All electrical mating surfaces shall be made of noncorrosive material.
- Each component of the flasher shall be identified by a circuit reference symbol. This identification may be affixed to the printed circuit board(s), the cover of the unit, or in the assembly drawing provided with the unit.

Electrical Characteristics:

The output circuit rating shall be the minimum rating for a tungsten lamp or gas tubing transformer load over a voltage range of 60 to 135 V at 60 Hz and shall not be de-rated for operation over the temperature and humidity range specified in Section A615.

Input to the flasher shall consist solely of the 60 Hz alternating current power source. This input shall supply the power for the output circuit and also provide power to the flasher logic. The flasher shall "turn on" within 5 degrees of the 0 V point of the alternating current line sinusoid and shall "turn off within 5 degrees of the zero current point of the alternating current line sinusoid. The flasher need not "turn on" within 5 degrees of the zero point of the alternating current sinusoid for the first flash cycle (on-off cycle) after the initial application of alternating current power to the flasher.

The "flashing" voltage output shall provide not less than 50, nor more than 60 flashes per minute with an on period of 50 ± 5 percent.

The flasher output shall have a dv/dt rating of 100 V per microsecond at 70°F (21°C).

The flasher output shall have a peak standoff voltage of 480 V or greater at 70°F (21°C).

The output current from the flasher through the load when the flasher is in the off state shall not exceed a maximum of 15 mA RMS.

The combined load on circuits 1 and 2 of a Type 1 flasher shall not exceed 20 A.

A Type 3 flasher shall have circuit 1 on when circuit 2 is off, and vice versa. The maximum off period when both circuits are off, or the maximum on period when both circuits are on, shall not exceed 17 mA during the transition from off to on and on to off.

A678-4.3 Pin Assignment

Pin assignments for Type 1 and Type 3 flashers shall be as follows:

PIN NUMBER	FUNCTION
*7	Load Circuit 1
*8	Load Circuit 2
9	Chassis Ground
10	AC (-) Common
11	AC (+) Hot
12	No Connection

*These pins (7 and 8) are electrically connected internally in the flasher for a Type I flasher.

A678-5 Time Switch

A678-5.1 General Requirements

A time switch is a 24-hour timer which controls the daily switching operation of circuit contacts at preselected times.

A Type 1 time switch contains a single circuit contact and a solid state timer with at least 48 programmable on and off times.

A Type 2 time switch contains two circuit contacts and a solid state timer with at least three independently programmable on and off times per circuit.

A Type 3 time switch contains three circuit contacts and a solid state timer with at least three independently programmable on and off times per circuit.

A678-5.2 Design Requirements

A678-5.2.1 Timing

Solid state timing shall be accomplished by digital circuits utilizing the power line 60 Hz frequency as the normal timing reference. Time-of-day shall be settable and displayed in maximum increments of one minute.

A678-5.2.2 Programming

Programming for selection of contact openings or closures shall be provided in maximum increments of one minute for Types 1 through 3 time switches.

A day omit device or circuit shall be provided with Types 1 through 3 time switches to omit the programmed switching operation for any combination of up to three days of the week. A positive means of indicating the day of the week shall be provided with Types 1 through 3 time switches.

A678-5.2.3 Reserve Power

Type 1, Type 2, and Type 3 solid state time switches shall be provided with a better backup circuit which maintains time during a power failure of up to 10 hours. The timing accuracy of battery backup circuits during a power failure shall be ±0.5 seconds.

A678-5.3 Output Circuit Contacts

Each output circuit contact shall be rated for a 3 A, 115 V AC load. The output circuit contact shall have 115 V AC present when the timer turns the circuit on.

A678-5.4 Construction Requirements

The time switch shall be enclosed in durable sheet aluminum or approved alternate housing. A terminal strip or screws shall be provided with the time switch for AC power and all output circuit contacts.

A678-6 Transfer Relay

A678-6.1 General Requirements

A transfer relay shall be used for transferring control of the intersection signal indications from the signal load switches to the flasher and vice versa.

A678-6.2 Design Requirements

The transfer relay shall be of electromechanical design. The transfer relay shall be designed to plug into Cinch-Jones sockets or approved equal. The transfer relay shall be enclosed in a case and shall have the manufacturer's name and part number on the case. The transfer relay contacts shall have a minimum current rating of 10 A at 115 V AC (RMS).

A678-7 Master Clock Unit

A678-7.1 Operational Requirements

The master clock unit shall be provided with a minimum of six independent circuits which are controlled by preprogrammed time-of-day events. Programming of a time-of-day event shall include, as a minimum, the following parameters:

- Time that the event begins (output(s) turn on)
- Time that the event ends (output(s) turn off)
- Output(s) that are controlled by the event
- Day of the week that the event occurs

The beginning and ending of a time-of-day event shall be programmable in increments of one minute. The master clock unit shall be designed so that a minimum of ten time- of-day events can be programmed for each day of the week, for a total of 70 time-of-day events per week. The time-of-day events shall be repeated on a weekly basis.

A678-7.2 Design Requirements

The clock circuit of the master clock unit may use either the 60 Hz AC line or a crystal oscillator as a time reference. If a crystal oscillator is used as a time reference, the time deviation of the oscillator shall be less than or equal to 0.0015 percent per day.

The real time of the master clock unit shall be settable to the nearest second. The clock shall display the day of the week, hours, minutes, and seconds in military clock (24-hour) time. Controls shall be provided for setting the day, hours, minutes and seconds.

The master clock unit shall be furnished with a rechargeable battery which will maintain the real time and program memory during power failures of up to 24 hours. The battery charging circuit shall be automatic and contained in the master clock unit. The master clock unit shall be designed to operate on 120 V AC, except during power failures.

The outputs of the master clock unit shall be rated at 3 A at 115 V AC (RMS).

A678-7.3 Construction Requirements

The master clock unit shall be contained in a durable housing, designed for mounting on a shelf. The inputs and outputs of the master clock unit shall be made through a connector approved by the FDOT. The chassis connector shall have pins.

A678-8 General Requirements for Type 170 Traffic Controller Accessories

A678-8.1 CV Monitor (Model 210E) 16 Channel Monitor

This subsection covers the requirements for signal CV monitors of solid state rack-mount design, interchangeable with the same type of units of different manufacture. A CV monitor shall be provided and wired into the cabinet with any Model 170E controller assembly utilizing solid state load switches for controlling the signal head indicators. The following illustrations are provided:

Figure 678-1: Model 210E CV Monitor Wiring Chart
Figure 678-2: Model 210E CV Monitor Connector Pin List
Figure 678-3: Model 210E CV Monitor Red Input Connector Pin Assignments.
Figure 678-4: Model 210E Red Monitor Program Board
Figure 678-5: Model 210E Red Monitor Program Board Schematic
Figure 678-6: Model 210E CV Monitor

A678-8.2 General Requirements

a) A front panel indicator labeled "CONFLICT" shall be provided. The indicator shall illuminate when there is a FAILED state caused by conflicting channels and go off only by Unit Reset Issuance.
b) The output relay contact for FAILED state shall be "CLOSED".
c) A second output circuit (STOP TIME - controller input) shall be provided to sink a NPN Open Collector Transistor upon FAILED state. The transistor shall be rated to sink a minimum of 50 mA up to 30 V DC. A blocking diode shall be provided on the transistor output to prevent feeding back power into the controller unit.
d) An internal SPST LOGIC toggle switch shall be provided on the CV monitor unit to activate the watchdog timer (WDT) function. When the switch is ON, the WDT circuitry shall be active. The switch shall be mounted on the module PCB in a readily accessible location.
e) The Front Panel RESET switch shall be tied to the External Test Reset Input Line (Pin Z). The external Line shall be optically isolated from internal circuitry.

f) Any dark signal due to loss of signal output to field terminals shall cause the monitor to trip.
g) The green, yellow, and all red indications for each phase shall be monitored separately with respect to a loss of signal on any of the three inputs per channel.
h) Upon energizing the manual reset button, the controller shall start timing the major street (movements 2 and 6) "through" green interval.
i) Absence of signal indications due to burnt-out signal lamps shall not be considered as a conflict.
j) The monitor shall have the required circuitry to allow the early detection of a conflict caused by a green signal "hang up" (That is any green output which remains on when the controller has transferred to a yellow output) by starting the conflicting timers as soon as a yellow appears with the corresponding green still energized. The monitor shall not wait until a conflicting green is displayed to time the conflict. This shall preclude the presentation of a conflicting signal display at the intersection.
k) During the all red clearance (if used) the monitor shall check all inputs for faulty signal display and shall react to these faulty indications during the all red clearance period. During this period the only inputs that should be active would be the reds; therefore, the monitor shall detect any defaults, such as red/green, red/yellow, green, and yellow/red.
l) The monitor shall have circuitry to prevent the controller from being operated with the monitor disabled due to a faulty reset button or a constant external reset input. The unit shall monitor the state of the reset button and external reset input. While a reset command is detected from either input, the monitor shall remain in the reset mode with the output relay energized and monitoring functions disabled. If the reset command lasts for a continuous duration of 15 seconds or more, the monitor shall automatically enter the normal mode of operation and begin monitoring all functions, ignoring the state of the reset inputs until they are removed or reapplied.
m) The monitor shall be capable of detecting incorrect signals applied at the field terminals of each vehicular movement (green, yellow or red). Should a voltage be present on more than one or none of the inputs (green, yellow or red) of a channel, the unit shall begin timing the duration of this condition. If this condition exists for less than 700 ms, the unit shall not trigger. If this condition exists for 700 ms or more, but less than 1000 ms, the unit may or may not trigger.
n) When the AC+ line voltage drops below the drop-out level of 98 (±2)V AC RMS, the CV monitor unit shall suspend all fault monitoring functions, de-energize the output relay, enable the Stop Time output to the controller, and place the intersection on "Soft" flash. The power light-emitting dioxide (LED) (AC indicator) on the front panel shall flash on and off at a rate of 2 Hz to indicate the Brown-Out status.

These requirements are needed to prevent a possible "Dark Intersection" conditions in the event that a power brown-out causes the cabinet controller to release control of the intersection and to prevent a possible lockup of the CV monitor unit due to a "RED FAIL" condition caused by a power brown-out.

A678-8.3 Conditions Sensed

The CV monitor shall render reliable detection and cause a relay output contact condition (FAILED state) when sensing the following:

a) The +24 V DC power supply voltage below the specified threshold.
b) A WDT time-out condition.
c) Conflicting field output circuits ON together.

A678-8.4 Failed State Output Circuits

a) An electro-mechanical relay shall be provided to switch an output circuit during a FAILED state. The relay coil shall be energized in a NON-FAILED state.
b) The relay contacts shall be rated for a minimum of 3 amperes at 120 VAC and 100,000 operations. Contact opening/closing time shall be 30 ms or less.

A678-8.5 Monitor Unit Reset

a) A momentary SPST CONTROL switch labeled "RESET" shall be provided on the unit front panel to reset the monitor unit circuitry to a NON-FAILED state. The switch shall be so positioned on the front panel that the switch can be operated while gripping the front panel handle.
b) A reset issuance (Unit Reset) shall be a one time input to prevent the monitor from constant reset.

A678-8.6 Power Supply

a) All monitor logic and driver power shall be generated from an internal unit power supply except for the WDT and +24 V DC cabinet voltage sense circuits. The WDT sense circuit power may be derived from either power supply.
b) Circuits on the monitor that are "powered" by the +24 V DC cabinet power supply shall be optically isolated from those deriving their power from the CV monitor unit internal supply. The monitor shall not draw more than 500 mA from the +24 V DC cabinet power supply. Failure to provide reliable operation voltage levels shall cause a FAILED state.

A678-8.7 Conflicting Field Output Circuits

a) The CV monitor unit shall monitor up to 32 field output circuits using a 16-conflicting channel (Green and Yellow outputs logically OR'd internally together) comparison setup.

The specified associated cabinet output file assignment, or operated selected output switches, will determine channel assignment.

b) All monitored field output voltages shall be measured as true RMS responsive (up to 3 kHz) to both positive and negative alternations of the sine wave and the full cycle. The calculated value shall be averaged over a minimum of two cycles. If digital means are used in calculating RMS, a minimum of two samples shall be taken per alteration.
c) Sensed conflicting field output voltages 25 V AC or greater, for a duration of 4502 ms or longer, shall cause a FAILED state.
d) Sensed conflicting field output voltages 15 VAC or less, OR voltage having a duration of 200 ms or less, shall NOT cause a FAILED state.
e) Sensed conflicting field output voltages between 15 and 25 V AC, for durations between 200 and 450 ms. may or may not cause a FAILED state.
f) The conflict monitoring circuitry shall be capable of detecting both a positive and negative half-wave failure under the foregoing conditions.
g) A FAILED state caused by sensing voltage conflicts shall be reset only by the Unit Reset.
h) 16 Indicators shall be provided on the unit front panel to indicate if the channel output is sensed ON. The indicators shall remain ON in a latched state during a FAILED state unless unlatched by a Unit Reset or a unit loss of power during said FAILED state.

A678-8.8 Power Supply Monitor

a) The CV monitor unit shall sense an external +24 V DC power supply voltage.
b) Voltages sensed at +18 V DC or below, for a duration of 500 ms or longer, shall cause a FAILED state.
c) Voltages sensed at +22 V DC or above shall NOT cause a FAILED state.
d) Voltages sensed below +22 V DC, for a duration of 200 ms or less, shall NOT cause a FAILED state.
e) All timing and voltage conditions other than those specified above may or may not cause a FAILED state.
f) A FAILED state caused by sensing the power supply shall illuminate a front panel indicator light labeled "V DC FAILED." The indicator shall remain ON until a Unit Reset is issued.
g) Only Unit Reset shall reset the power supply sense circuitry from a FAILED state.

A678-8.9 Watchdog Timer Monitor

a) WDT circuitry shall be provided to monitor a controller unit output line state routed to the CV monitor unit at its assigned pin. The WDT circuitry shall sense any line state change and the time between the last change. No state change for 1.5 (+0.1) seconds shall cause a FAILED state. The timer shall reset at each state change in a NON-FAILED state.

b) Only the Unit Reset, or a WDT inactive due to the voltage sense, shall reset the WDT from a FAILED state.
c) A FAILED state caused by the WDT shall illuminate a front panel indicator light labeled "EDT ERROR". The indicator shall remain ON until a Unit Reset is issued.
d) The WDT circuitry shall sense the incoming V AC line and, when the voltage falls below 98 (±2) V AC for 50 (±17) ms, shall inhibit the WDT function. When the WDT circuitry senses the incoming V AC line rise above 103 (±2) V AC for 50 (±2) ms, the WDT shall become active. A hysteresis between the Voltage Inhibit and the Voltage Active Settings shall be a minimum of 3 volts.

A678-8.10 Conflict Programming Card

a) A plug-in PCB Programming Card shall be provided in the CV monitor unit. The card shall plug into the unit through a slot in the unit from panel. The card shall contain 120 diodes (#1N148 or equal). Each diode shall match one through16 channels of possible conflict. The programming card shall be logically labeled and laid out for easy identification of the diodes by channel. With diodes in place, all output channels being monitored shall be in conflict. When the diode (anode to numerical pins and cathode to alphabetical pins) has been removed, the channels shall be defined as non-conflict.
b) A pad for 16 yellow inhibit jumpers shall be provided. Placement of the associated channel jumper between the channel yellow pin and the yellow inhibit common shall disable sensing of the yellow channel.
c) The programming card shall mate with a PCB 28/56S connector. The card shall be provided with card ejector. The monitor unit shall provide a mechanically sound card and connector support including continuous card guides. When the programming card is resident in the unit, the card's front end shall be flush with the unit's front panel.
d) Pins 16 and T shall be connected together on the programming card. Removal of the card shall be sensed as a conflicting FAILED state.

A678-8.11 Integrated Circuits

Integrated circuit (IC) shall be interpreted as covering monolithic multi-element semiconductor circuits existing on a common substrate and enclosed in a continuous package. The foregoing shall also include encapsulated bridge rectifiers, resistors, etc. Neither bilateral trigger diodes (or similar) devices nor hybrid devices shall be considered as integrated circuits. All integrated circuits shall have the manufacturer's name and/or identification symbol/logo and IC part number clearly and legibly printed.

A678-8.12 IC Sockets

All IC units, hybrid and resistor/capacitor packages consisting of eight or more pins, shall be mounted to the printed circuit board using the approved IC socket listed below or an approved equivalent:

a) AUGAT Inc., Series 200, beryllium copper tinned contacts.
b) AMP inc., Diplomat Low Profile Sockets Series, beryllium copper tinned contacts
c) Texas Instruments, Low Profile Series C-87, beryllium copper tinned contacts.

IC sockets for PROMS, EPROMS, and EEPROMS are required to be low Insertion/Withdrawal-LIF lock type connector/socket, beryllium copper tinned contacts, available from the above manufacturers.

A678-9 Power Supply Module (Model 206)

A678-9.1 General

A power supply shall be provided to supply +24 V DC to the Output File for use by its associated devices.

A678-9.2 Design Requirements

The power supply shall be of a ferro-resonant design having no active components.

The front panel shall include AC and DC fuses, power indicator On light, and test points for monitoring the output voltages.

The Module Chassis shall be vented. Its top and sides shall be open except for unit supports.

The module shall be held firmly in place in the PDA assembly by its stud screw, assembly connector support panel, and wing nut.

Terminal screw size shall be 10-32 for TBK T1, T2 and T4; and 6-32 for TBK T3.

A678-9.3 Electrical Characteristics

a) Line regulation shall be 2 percent from 90 to 135 V AC at 60 Hz, plus an additional 1.6 percent for each additional 1.0 percent frequency change.
b) Load regulation shall be 5 percent from 1 to 5 amperes with a maximum temperature rise of 30°C (86°F) above ambient.
c) The design voltage shall be +24 (± 0.5) V DC at full load 30°C (86°F), 115 VAC incoming after a 30-minute warm-up period.
d) The full load current shall have a minimum of 5 amperes.
e) Ripple noise shall not exceed 2 volts peak-to-peak and 500 millivolts RMS at full load.
f) The power supply line voltage shall be between 90 and 135 V AC.

g) A 70 percent (minimum) efficiency shall be met.
h) Circuit capacitors shall be rated for 40 volts, minimum.
i) Two 0.5 ohm (½ ohm), 10 watt minimum wire-wound power resistors with 0.2 μH inductance shall be provided (one on the AC+ power line and one on the AC- line). Three MOV surge arrestors rated for 20 joules minimum shall be supplied between AC- and EG; between AC+ and EG; and between AC- and AC+. A 0.68 μF capacitor shall be placed across AC- and AC+ between the two power resistors and the MOVs.

A678-9.4 Physical Characteristics

The physical attributes of the Model 206 power supply module are shown in Figure 678-10.

A678-10 Power Distribution Assembly

A678-10.1 PDA #2

A678-10.1.1 Required Equipment

The following equipment shall be provided with the power distribution assemblies:

1) Duplex NEMA 5-15R Controller Receptacle.
2) Duplex NEMA 5-15R Equipment Receptacle (one with ground-fault interruption [GFI]).
3) One pole 50 amperes minimum, 120 V AC Main Circuit Breaker.
4) Six single pole circuit breakers, 15 amperes, with auxiliary switch feature, 120 V AC Signal Buss.
5) Two pole, ganged, 20 amperes, 120 V AC Flash Buss Circuit Breaker.
6) Relay Contactor rated minimum 60 amperes, 120 V AC.
7) Model 204 Flasher Unit and Socket.

A678-10.1.2 General Requirements

1) Rating of breakers shall be shown on the face of breaker or handle. Breaker function shall be labeled below breakers on front panel.
2) The first equipment receptacle in the circuit shall have GFI as defined in the National Electrical Code. Circuit interruption shall occur on 6 mA of ground-fault current and shall not occur on less than 4 mA of ground-fault current.
3) The AUTO/FLASH switch, when placed in FLASH position (down), shall energize the contactor (MC) coil. When the switch is placed in the AUTO Position (up), the switch packs shall control the signal indications. The switch shall be a single-pole, single-throw (SPST) toggle control switch.
4) The FLASH indicator light labeled "Flash On" shall be mounted on the PDA front panel. The lamp shall be driven by Flasher Unit/Output through the signal buss circuit breaker.

5) All conductors from the Power Distribution Assembly routed to the cabinet wiring shall be connected to the terminal block on the common side, except for the AC power conductor between the service terminal block and main circuit breaker. All internal conductors terminating at the blocks shall be connected to the other side of the blocks.
6) Ganged circuit breakers shall be certified by the circuit breaker manufacturer that their circuit breakers shall gang trip.
7) Signal buss circuit breaker:
   a) Six single pole 15-ampere circuit breakers with auxiliary switch feature and medium trip delay characteristic shall be provided.
   b) The six breakers shall be wired and routed per the line diagram. The breaker auxiliary switch circuit shall be open when the breaker is in the ON position. The auxiliary circuits shall be wired in parallel so that any tripped breaker shall energize the contactor coil, flash transfer relay coils, and the "FLASH ON" indicator. The auxiliary contacts shall be rated at 5 amperes, 120 V AC minimum (fast on type connection)

A678-10.2 Physical Characteristics

1) The physical details of PDA #2 are shown in Figure 678-11. The front panel details of PDA #2 are shown in Figure 678-12. The mounting details of the connector/stud are shown in Figure 678-13 of Figure 678-11.
2) The interconnection wiring of PDA #2 is illustrated in Figure 678-14.
3) The circuit breaker one line diagram is illustrated in Figure 678-15.

A678-11 Output

A678-11.1 Output File #1

A678-11.1.1 General Requirements

a) The output file shall be provided with marker strips to identify switch packs when mounted in the file.
b) Switch pack connectors, monitor unit connectors, flash transfer relay sockets, and flash programming connectors shall be accessible from the back of the output file without the use of tools or removal of any other equipment.
c) TBK 01 and 03 terminal positions shall be labeled functionally. A permanent label reading "Channels 9 and 10 separated" placed on the right output file mounting flange.
d) Field wire terminal blocks shall be mounted vertically on the back of the assembly. The output file shall have three terminal blocks with 12 positions. Terminal position screw size shall be 10-32.

e) The flash transfer relays shall be heavy duty type. The relay coil shall be energized only when the signals are in the flashing operation and the police panel ON/OFF switch is ON. The relay shall transfer the field outputs from switch pack to flash control. The transfer shall not interrupt the controller unit operation.
f) The depth of the file shall not exceed 368 mm (14½ inches).
g) The flash programming connectors shall be Molex Type 1375 or approved equivalent. The receptacle shall be mounted on the file with a programmable plug connected. The plug connector, with programming jumpers, shall be furnished for each circuit to allow red or yellow flash programming. Plug pins shall be crimped and soldered.
h) TBK 01 and 03 terminal screw size shall be 8-32 and TBK 02 and 04 shall be 6-32.
i) The output file shall be capable of containing 12 Model 200 switch packs, four flash transfer relays, and the Model 210E monitor unit. All 552-A cabinets shall be furnished by the manufacturer/vendor with all equipment supplied.
j) The red and yellow output circuits of switch packs 1, 2, 3, 4, 5, 6, 7, and 8 shall be made available at individual pack Molex receptacle/plug connection for flash selection. Eight red and four yellow Molex plugs shall be provided.
k) The monitor unit compartment, including the housed Model 210E monitor unit exclusive of handle, shall extend no farther than 31.7 mm (1¼ inches) in front of the 19-inch rack front surface. The switch pack socket connector front surface shall be no more that 8½ inches deep from the front of the output file.

A678-11.1.2 Physical Details

a) Figure 678-16 provides detailed information concerning the physical layout of the output file No. 1.
b) Figures 678-17, 678-18, and 678-19 provide in-depth detail concerning switch pack, logic relay, and isolation relay mounting within the output file.
c) The following illustrations are provided:

Figure 678-20: Output File No. 1 Interconnection Wiring
Figure 678-21: Output File No. 1 Terminal Assignments
Figure 678-22: Interconnect Harness Output File No. 1 to Field Services Panel

A678-12 Transfer Relay (Model 430)

A678-12.1 General Requirements

A transfer relay, also referred to as a flash transfer relay, shall be used for transferring control of the intersection signal indications from the signal load switches to the flasher, and vice versa.

A678-12.2 Design Characteristics

a) The transfer relay shall be of electro-mechanical type for continuous duty.
b) The transfer relay shall be designed to plug into BEAU S-5408 sockets or approved equivalent.
c) The transfer relay shall be enclosed in a removable, clear plastic cover which shall afford maximum protection from foreign materials. The manufacturer's name, electrical rating, and part number shall be placed on the cover. They shall be permanent, durable, and readily visible.
d) Each relay shall be provided with DPDT contacts. Contact points shall be of fine silver, silver alloy or superior alternative material. Contact points and arms shall be capable of switching 20 amperes at 120 V AC tungsten load per contact once every two seconds with a 50 percent duty cycle for at least 250,000 operations without contact welding or excessive burning, pitting or cavitation.

A678-12.2.1 Electrical Characteristic

a) The transfer relay contacts shall have a minimum current rating of 20 amperes at 120 volt AC RMS.
b) The relay coil shall have a power consumption of 10 volt-amperes maximum.
c) Each relay shall withstand a potential of 1500 V AC at 60 Hz between insulated parts and between current carrying or non-carrying parts. Each relay shall have a one-cycle surge rating of 175 amperes RMS.
d) The electrical configuration of the Model 430 flash transfer relay is provided in Figure 678-23.

A678-12.3 Pin Assignments

Pin assignments for the transfer relay are shown in Figure 678-24.

A678-13 Input File

A678-13.1 General Requirements

a) The input file consist of a 14 slot card cage which, when fully populated, serves to house 13 two-channel loop detector modules, and one current monitor module.
b) These modules shall populate the 14 positions of the input file, from left to right when viewed from the front, as follows:

SLOT	FUNCTION	CHANNEL #
1	Loop Detector # 1	1
2	Loop Detector # 2 (stop bar) & # 2 (regular)	2
3	Loop Detector # 2 (regular) & # 2 (advance)	2
4	Loop Detector # 3	3
5	Loop Detector # 4 (stop bar) & # 4 (regular)	4

6	Loop Detector # 4 (regular) & # 4 (advance)	4
7	Loop Detector # 5	5
8	Loop Detector # 6 (stop bar) & # 6 (regular)	6
9	Loop Detector # 6 (regular) & # 6 (advance)	6
10	Loop Detector # 7	7
11	Loop Detector # 8 (stop bar) & # 8 (regular)	8
12	Loop Detector # 8 (regular) & # 8 (advance)	8
13	System Sensor Loop Detectors	S1 &S2
14	Current Monitor (Model D292)	

A678-13.1.1 Physical Requirements

a) The input file physical dimensions shall be a maximum of 17.5 inches wide by 5.25 inches high with 3/4 inch mounting flanges for a 19-inch rack (See Figure 678-25).

b) The back plane shall NOT consist of printed wiring. Any back plane interconnection shall be by discrete wiring only.

c) Each of the first 13 back plane connectors shall be a double row, 44 (2 by 22) position connector utilizing 0.156-inch finger spacing. These connectors shall be designated C1 through C13.

A678-13.1.2 Electrical Characteristics/Pin Assignments

a) The 14 input file slot shall have a hard-mounted standard Cinch C 2 by 22 pin connector. This slot (the right hand slot when viewed from the front) is reserved for the current monitor.

b) The 14 input file connectors shall be hardwired as follows:

Cn-F	Channel 1 Output
Cn-W	Channel 2 Output
Cn-D	Channel 1 Input +
Cn-E	Channel 1 Input ¬
Cn-J	Channel 2 Input +
Cn-K	Channel 2 Input ¬
Cn-L	Equipment Ground

A678-14 Current Monitor

A678-14.1 General Requirements

a) A solid state current monitor will be used to monitor the flow of current through various conductors carrying power to a lamp or groups of lamps. It shall have the capability of detecting the failure of any one in eight lamps for any single channel. In the event of a lamp failure, the current monitor will signal the controller that one or more lamps have failed. It shall also identify from which physical direction the failure occurred. The current monitor shall be a passive device; it shall sense the flow of current without actually being in series with the current flow. This shall be done by toroidal sensors.

b) The monitor shall have 16 analog channel inputs. These inputs shall be optically isolated high voltage inputs. The monitor shall have four optically isolated programmable alarm outputs.

A678-14.2 Design Requirements

A678-14.2.1 Physical Characteristics

a) Overall dimensions of the monitor shall be such that it fits into the standard input file slot.
b) The monitor shall plug into slot 14 of the input file.
c) The connector shall be compatible and approved by the engineer.
d) Continuous edge guides shall be provided on the monitor.
e) The monitor's control circuitry and switches shall be readily accessible by the use of a screwdriver or wrench. Only one type of screw head end (slotted or Phillips) shall be used throughout.
f) Each monitor shall be so constructed that persons inserting or removing the module will not be exposed to any parts having live voltage. A handle shall be attached to the front of each monitor to facilitate the monitor insertion or removal from its mating connector.
g) The front panel of the monitor shall be provided with four indicators. The indicators shall be vertically centered on the front panel with top and bottom indicators no more than 1 inch from the panel vertical center.
h) The indicators shall indicate the output state of the monitor.
i) All printed circuit boards shall be made from NEMA (FA-4) glass epoxy, or equivalent (see NEMA Standards Publication for *Industrial Laminated Thermosetting Products, Publication No. LI 1-1971*), or latest revision thereof).
j) Circuit boards exceeding 2 inches in any dimension shall have a nominal thickness of at 1/16 inch. Circuit boards not exceeding 2 inches in any dimension shall have a nominal thickness of at least 1/32 inch.
k) The walls of all plated through holes shall have a minimum copper plating thickness of 0.001 inch. All circuit tracks shall have an equivalent conductivity of at least 2 ounces per square foot of copper. All electrical mating surfaces shall be made of non-corrosive material.
l) Each component of the monitor shall be identified by a circuit reference symbol. This identification may be affixed to the printed circuits board(s), the unit cover, or in the assembly drawing provided with the unit.

A678-14.2.2 Electrical Characteristics

a) The monitor shall operate from a +24 volt DC power source.
b) Each channel input shall consist of a signal and an analog ground connection.

A678-14.3 Pin Assignments

Pin assignments for the current monitor shall be as illustrated in Figure 678-26.

A678-15 Pedestrian Isolator Units

A678-15.1 Pedestrian Detector Isolation Boards

Pedestrian detector isolation shall be provided through the use of a PC board type pedestrian isolator board that contains its own power supply and a minimum of four pedestrian isolator circuits. This board shall be connected via the use of a terminal block to the auxiliary field service panel as shown in Figure 676-38. All cabinets shall employ the use of this board; likewise, the board shall be totally interchangeable with any cabinets so furnished. Should the need arise to replace this board, common hand tools shall be required to perform this operation. Refer to Figure 676-39 for layout of the board. The vendor shall also make this pedestrian isolator PC board a readily available spare part.

A678-16 Generator Power for Signalized Intersections Retrofit

A678-16.1 Description

This Section specifies the generator power for signalized intersection controller cabinet retrofits. The specifications for new controller cabinets are included in A676-1 CONTROLLER CABINET. The FDOT's ***Guidelines for Generator Power for Signalized Intersection*** is located at: http://www.dot.state.fl.us/trafficoperations/Traf_Sys/terl/apl4.shtm.

A678-16.2 Design

Refer to the FDOT's Design Standards regarding connections and dimensions.

A678-16.3 Materials

A678-16.3.1 Transfer Switch

The transfer switch shall be mounted on the side of the controller cabinet, as close as possible to the AC main circuit breaker, away from any pedestrian walkway; and shall not be mounted on a controller cabinet door. The bottom of the transfer switch shall be located at least 24 inches above the concrete pad to avoid flood and splash water. The transfer switch outside cover shall be labeled "Emergency Generator Connector" in red.

The transfer switches shall be sized to meet the amperage rating of the AC power service overcurrent protection rating and shall be provided with manually operated toggle type transfer switches.

To provide for automatic transition from generator power back to utility power after utility power is restored, an automatic transfer switch may be used instead of a manual transfer switch.

A678-16.3.1.1 *Ratings*

The transfer switch shall:

- Withstand closing and interrupting power ratings of 20,000 amps.
- Be rated for continuous duty at 100 percent load.
- Conform to the applicable requirements of UL 1008 for emergency system total load.
- Be fully rated for all types of loads, inductive and resistive, without de-rating, either open or closed.

A678-16.3.1.2 *Construction*

The transfer switch shall have a lockable door with a tamper-resistant hinge to completely enclose all components, and be furnished with a lock with two #2 keys. The door shall have a movable plate to cover the opening for the generator cable when the generator is not connected. The enclosure shall be constructed of heavy-duty, 12 gauge, Type 5052-H32 aluminum or rust and corrosion-resistant stainless steel rated for outdoor use.

The transfer switch shall be constructed to prevent cross connection of power sources.

An integrally mounted NEMA L5 male power inlet rated at 125V shall be provided inside a lockable enclosure at the front of the transfer switch.

The transfer switch shall be capable of being operated manually under fully rated load conditions.

Use a single pole 120V transfer switch. The generator and utility supply source neutral leads are tied together in the cabinet. The transfer switch only switches the phase conductor (hot) and not the neutral.

A678-16.3.1.3 *Enclosure*

The enclosure shall meet the requirements of NEMA 3R, 4, or 4X as rated for outdoor environments. The transfer switch shall include a 3/16-inch thick ethylene propylene diene monomer, closed-cell sponge rubber gasket, meeting UL-recognized component requirements.

A678-16.3.1.4 *Finish*

NEMA 3R aluminum, or NEMA 4 or 4X stainless steel may be left unpainted.

A678-16.3.1.5 *Accessories*

Provide a “utility-on” light that can be observed from outside of the transfer switch enclosure to indicate that the utility power has been restored.

A678-16.3.2 Direct Connection

For direct connection operations, the egress cover shall be weather-tight and lockable. The AC service neutral lead shall be connected to the cabinet when the generator is connected.

A678-16.3.3 Generator

Sections 702.5 and 702.6 of the NEC govern the selection and use of standby power systems and provide requirements for transfer equipment. At minimum, use a 120V, 60 Hz, 3000-watt generator, or two 1500-watt generators hooked in parallel using a parallel kit with 30-amp locking plug with inverter. For existing generator without inverter, a power conditioner shall be installed to ensure clean sinusoid AC power to the controller and conflict monitor. The generator shall be sized to match the full load requirements of the controller cabinet. Generators shall be able to operate continuously for eight hours on a single tank of fuel.

A678-16.3.4 Cable

For transfer switch operations, use the power cord that meets or exceeds the requirement of transfer switch. The amperage of the conductors and twist-lock connectors from the generator terminals to the disconnect switch shall match or exceed the output rating on the generator’s overcurrent protection. Use 50 feet or less of #10 AWG or larger wire.

A678-16.3.5 Uninterrupted Power Supply

The uninterrupted power supply units listed on the FDOT’s Approved Product List shall be used when required.

SECTION A699
INTERNALLY ILLUMINATED SIGNS

A699-1 General

This Section specifies the requirements for certifying and listing an Internally Illuminated Street Name or Guide Sign on the FDOT's Approved Product List (APL). Certification for an internally illuminated street name sign will be limited to sign assemblies that are no more than 18 square feet in area and weigh no more than 144lbs. Internally illuminated street name signs that exceed maximum area or weight limitations will not be listed on the Approved Product List and must be submitted to the Project Engineer for approval in accordance with Section 699 of the Standard Specifications for Road and Bridge Construction (SSRBC).

A699-2 Standard Housing

The body of the sign shall consist of an aluminum one piece box type enclosure and separate hinged door assembly. The tops of the sign body shall include drip rails or other means to prevent water from entering the sign housing. A minimum of two .25-inch drain holes shall be located in the bottom of the sign housing no more than one foot from each end of the sign. Alternately, a minimum of four .125 inch drain holes may be provided. Drain holes shall be screened. Fluorescent sign reflectors shall be able to be removed without the use of any tools.

Signs shall have removable sign faces. The aluminum door shall be of one piece (all seams welded) frame construction. The sign face shall be secured by attaching four frame plates (bottom, top and two sides), secured by bolts and screws, holding the sign in place. Slide-in grooves may only be submitted for Edge-lit signs. Slide in grooves will not be accepted for fluorescent signs. Each door shall have a full length stainless steel hinge on the top or bottom edge. The hinge shall be concealed. If a door opens up, it shall have a bracket on each side to prop the door open during maintenance. Doors shall be continuously sealed with a UL listed foam gasket to prevent the entry of water into the sign housing. Gaskets shall be installed, continuously, on the door frame to seal the sign face to the door frame. Another strip shall be installed on the sign body matching where the door seals. Each door shall be secured from opening by a minimum of two (for 2 to 6 foot signs) or three (for signs longer than 6 feet) stainless steel 1/4-20 threaded studs (with thumb screw type wings) or ¾ turn (DZUS) fastener to prevent the door from opening when the sign is flexed. The threaded portion of the stud shall be a minimum of 1.5 inches long and shall screw into a captive nut assembly on the sign body.

A699-3 Edge-lit Housing

The outer dimensions of the sign assembly (excluding the mounting bosses) shall be standard widths of 15, 18, 20, and 24 inches, and standard lengths of 48 – 96 inches, at 6-inch increments. The maximum thickness of the sign shall not be greater than 3 inches.

The long edges of the sign shall be made from a single section of 6063-T5 aluminum extrusion. The ends caps shall be securely affixed to the frame and be removable to enable replacing panels and components. The overall weight, excluding mounting hardware, shall not exceed 6 pounds per square foot for single sided signs, and 8 pounds per square foot for double sided signs.

The manufacturer of the sign assembly shall furnish a certification stating the design and construction of the complete sign assembly, including the sign panels and sign mounting hardware, has been designed and constructed to withstand 150 mph wind loads meeting the requirements of the FDOT Structures Manual, Volume 9.

A699-4 Additional Requirements for Standard and Edge-lit signs

Signs shall be marked in accordance with A601.

Sign housing shall be constructed of aluminum. The sign assembly shall have one face unless specified otherwise in the plans. All seams shall be continuously welded for a water-tight seal.

All exterior surfaces of the assembly shall be powder-coat painted in accordance with Military Standard MIL-PRF-24712A or AAMA-2603-02. Finish must meet the requirements of ASTM D 3359, ASTM D 3363, and ASTM D 522.

All hardware such as nuts, bolts, screws, threaded studs, washers, etc. shall meet the criteria in 603 of the SSRBC.

The sign face shall be a translucent lens constructed of 0.125 inch (3.125 mm) high impact strength polycarbonate or acrylic meeting UL48. Letters shall be as detailed in the Contract Documents. Background shall be translucent retroreflective sheeting coated with a transparent, pressure-sensitive adhesive film. Green color shall meet the criteria as designated in SSRBC sections 700 and 994. Retroreflective sheeting shall meet the criteria of ASTM D-4956.

A699-5 Luminance

Illuminated Sign Face shall be illuminated evenly across the entire surface. Contrast ratio between the white and green surfaces shall be established by the lowest white measurement and the highest green measurement and shall be at least 4:1.

A699-5.1 Background

Minimum luminance for the green portion of the street sign face shall be no less than 87.5 lux. The luminance shall be determined by averaging a minimum of seven readings. Four of the readings shall be taken near the midpoint of a line that would span between the outside corners of the background and the outside corners of the legend. One reading shall be taken near the midpoint of a line that would connect the top corner readings. One reading shall be taken near the midpoint of a line that would connect the bottom corner readings. One reading shall be taken near the vertical and horizontal midpoint of the sign.

A699-5.2 Border and Lettering

Minimum luminance of the legend and border shall be 350 lux. The luminance shall be determined by averaging a minimum of 17 readings. There shall be a minimum of 1 reading from each letter in the legend. Readings within the legend shall alternate between the top, middle and bottom portion of each letter. Readings within top and bottom of the border shall be perpendicular to the top and bottom readings in the background. Readings within the sides of the border shall be taken parallel to the readings taken within each letter.

A699-6 Electrical

The electrical wiring shall be designed to meet NEC requirements for the light source provided. All wiring shall be copper wire. All internal electrical wiring must be tight and secure. An electrical power wire entrance compartment shall be supplied with the sign assembly and shall provide a weather-tight seal. The sign shall also include a replaceable fuse at the electrical power wire entrance compartment or inside the sign. All power supplies and ballasts shall be FCC approved and at minimum IP66 rated.

All signs shall have provisions for an integrated photoelectric cell.

Sign assembly shall be UL listed.

A699-7 Warranty

Ensure that the Internally Illuminated Sign and equipment furnished have a manufacturer’s warranty covering defects in assembly, fabrication, and materials, other than expendable items such as bulbs, for a minimum of 5 years.

SECTION A700
ELECTRONIC DISPLAY SIGNS

A700-1 Description

All Electronic Display Signs (EDS) must meet the physical display and operational requirements for warning or regulatory signs described in the Federal Highways Administration (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) and its companion document, the Standard Highway Signs Book (SHS).

EDS are specialized electronic signs that include dynamic display components. The term EDS refers to a general category of electronically enhanced signs that includes Electronic Warning Signs (EWS), Electronic Regulatory Signs (ERS), Electronic Speed Feedback Signs (ESFS), and Blank-Out Signs (BOS).

A700-2 Material

EWS, ERS, and ESFS must allow attachment to vertical and horizontal support structures as part of a single or double sign post configuration. Bolts must be used for load bearing attachments. BOS are not required to include static sign attachment provisions. All electronic assemblies must meet the requirements of FCC, Title 47 Subpart B Section 15.

A700-2.1 Requirements common to all EDS

All EDS must be designed to withstand the loads defined in the Florida Department of Transportation (FDOT) Structures Manual without deformation or damage. EDS, other than BOS, must provide an option to include flashing beacons. Printed circuit boards shall be protected with conformal coating. Housings that contain electronics shall be constructed of aluminum alloy sheet a minimum of .125 inches thick. Welding used during the construction of EDS must conform to the ANSI/AWS Structural Welding Code – Aluminum.

A700-2.1.1 General

EDS other than BOS shall include a Static Sign Panel with an integrated dynamic display. Signs included on the Approved Products List (APL) will be designated with a size and type category and may be listed with restrictions, such as “Requires District Traffic Operations Engineer Approval”, “school zones only”, or “low speed only”.

A700-2.1.2 Electronic Display Sign with Static Sign Panel

EDS that include both a static sign and dynamic display may be a modular system comprised of a static sign with an attached electronic display.

A700-2.1.2.1 Static Sign Panel

Static sign panels shall meet FDOT requirements for Highway Signing found in Section 700 of the Standard Specifications for Road and Bridge Construction.

A700-2.1.3 Electronic Display

Electronic displays shall appear completely blank (dark) when not energized. No phantom characters or graphics will be allowed under any ambient light conditions.

A700-2.1.3.1 Housing

Cover the electronic display panel with a non-glare transparent polycarbonate face to protect and seal the dynamic display and other internal electronics. The polycarbonate face must be a minimum 90 percent ultraviolet (UV) opaque and resistant to fading and yellowing. Electronic displays incorporated within static signs must be mounted to the back of the static sign face. The polycarbonate face shall not be recessed more than ¼-inch from the front of the static sign. The housing shall be National Electrical Manufacturers Association (NEMA) 3R rated and prevent unauthorized access. The housing shall include weather tight cable entry or connection points for any required power or data connections.

A700-2.1.3.2 Cabinet

Any equipment cabinets provided with the EDS must be listed on the APL.

A700-2.1.3.3 Optical, Electrical, and Mechanical Specifications for Display Modules

Ensure that all light emitting diodes (LED) operate within the LED manufacturer's recommendations for typical forward voltage, peak pulsed forward current, and other ratings. Component ratings shall not be exceeded under any operating conditions.

A700-2.1.3.4 LED and Pixel Specifications

Ensure that all LEDs used in the display have a wavelength output that varies no more than ±2 nanometers from the specified peak wavelength. Ensure that the display and LED pixel cone of vision is a minimum of 30 degrees (centered around the optical axis, or zero point, of the pixel). The cone perimeter is defined by the point where light output intensity is 50 percent of the intensity measured at the zero point of the pixel.

For all colors other than white, ensure that the sign display produces an overall luminous intensity of at least 9200 candelas per square meter when operating at 100 percent intensity. For white or full color matrix displays ensure that the sign display produces white with an overall luminous intensity of at least 12,400 candelas per square meter when operating at 100 percent intensity. Provide documentation that indicates the LED brightness and color bins that are used in each pixel. Ensure that LEDs are individually mounted on a PCB, and are able to be removed and replaced using conventional electronic repair methods. Encapsulated LEDs within a pixel are not allowed. ERS LEDs shall be arranged and powered in a manner that maintains a discernible message in the event of a single LED or pixel failure.

A700-2.1.3.5 Character Size, Fonts, and Graphics

The minimum numeral and letter size of the electronic display must meet or exceed the numeral and letter sizes prescribed in the MUTCD and SHS companion document. Fonts and graphics shall mimic the characteristics of fonts and graphics defined in the MUTCD and SHS.

A700-2.1.4 Electronic Display Controller

Any electronic display controller required for the operation of the EDS shall be housed within the sign and be equipped with a security lockout feature to prevent unauthorized use. The electronic display shall not be adversely affected by radio transmissions. The controller shall have the capability to provide a stipulated default message upon loss of controller function. A blank message is acceptable.

A700-2.1.4.1 Communication

The Electronic Display Controller shall possess a minimum of 1 serial interface with the ability to connect to a laptop computer. The serial data interface shall support multiple data rates from 9600bps to 115200 bps.

A700-2.1.4.2 Configuration and Management

Ensure that the sign is provided with computer software from its manufacturer that allows a user to program, operate, exercise, diagnose, and read current status of all sign features and functions using a laptop.

A700-2.1.5 Operation and Performance

Ensure that the EDS is visible from a distance of at least ¼ mile and legible from a distance of 400 feet for applications on roads with a speed limit less than 45 miles per hour (mph) and visible from a distance of at least 1/2 mile and legible from a distance of at least 650 feet for roads with speed limits 45 mph or higher. In both cases, the requirements must be met under both day and night conditions.

The electronic display shall automatically adjust brightness for day and night operation in order to meet or exceed visibility requirements. The EDS shall be equipped with a light sensor that accurately measures ambient light level conditions at the sign location. The EDS shall automatically adjust LED intensity based on the ambient light conditions in small enough increments that the sign's brightness changes smoothly, with no perceivable brightness change between adjacent levels. Stray headlights shining on the photoelectric sensor at night shall not cause LED brightness changes.

Message dwell time and message flash rate shall be individually programmable with a maximum flash rate of 150 flashes per minute.

A700-2.1.6 Mechanical Specifications

EDS mounting provisions and mounting hardware must accommodate sign weight and wind loading requirements of the FDOT Structures Manual. BOS must be designed to accommodate overhead attachment using a tri-stud signal hanger. Multiple tri-stud attachment points may be used to meet weight and wind loading requirements. Tri-stud attachment points must be weather-tight and structurally reinforced.

A700-2.1.6.1 Fasteners and Attachment Hardware

Use only nuts, bolts, washers, and other fasteners meeting Section 603 of the SSRBC.

A700-2.1.7 Electrical Specifications

All power inputs shall be fuse and reverse polarity protected. All EDS must be able to recover from power loss and return to their operational state without user intervention.

A700-2.1.7.1 Solar Power

Solar powered signs shall be capable of fully autonomous operation 24 hours per day, 365 days per year. Batteries shall be a standard 12 volt deep cycle battery suitable for the application and operating environment. Flooded lead-acid batteries are prohibited. Batteries must be capable of providing 10 days of continuous operation without sunlight. Charging system shall use a solar charge controller with temperature compensation. The system shall provide for automatic battery charging, overcharge protection, and have indications that display current status and faults.

A700-2.1.7.2 AC Power

AC powered signs shall be capable of operation from 89-135 volts with a frequency of 60 Hz ±3. Fluctuations in line voltage shall have no visible effect on the appearance of the display.

A700-2.2 Electronic Warning Signs

The EWS must be designed to alert road users to conditions that might call for a reduction of speed or an action, in the interest of safety and efficient traffic operations. EWS shall include a secure wireless connection to communicate with a nearby laptop.

A700-2.2.1 EWS Foreground/Background Colors

If a black background is used on the changeable electronic display, the color used for the legend must match the background color that would be used on a standard sign for that type of legend, in accordance with the MUTCD. Black EWS display backgrounds must be flat black (Federal Standard 595A-37038) with a reflectance value not exceeding 25 percent. EWS must utilize yellow LEDs with a peak wavelength of either 585 or 590 nanometers. EWS shall have a minimum 1-inch contrasting margin around illuminated characters or graphics.

A700-2.2.2 Speed Detector

EWS that detect or display the speed of approaching vehicles must be programmable for the posted speed limit and the maximum speed to display. When the detected speed exceeds the maximum programmed speed (high speed cut-off) threshold, the display will automatically blank. Alternately, the display may show an alert message such as "SLOW DOWN" when speeds above the maximum programmed speed threshold are detected.

The EWS shall detect when the posted speed is exceeded by 1 mph and then activate the alert. When the alert is activated, the display shall be able to flash at a rate of 50 to 60 cycles per minute. When no advancing traffic is detected, the display shall be blank. The speed detector shall not activate alerts for vehicles outside the display cone of vision.

The speed detector shall not be affected by normal radio transmissions. The EWS shall meet the requirements of FCC Part 90. The EWS shall not require an FCC operating license. The speed detector shall operate on 10.8 to 16.6 VDC and draw less than 3 amperes. The EWS shall monitor and display the speed of approaching traffic only. The EWS detector shall be able to accurately detect and determine the speed of approaching vehicles. The EWS shall be able to detect a motorized vehicle 1,000 feet in advance of the sign. The EWS shall be capable of measuring speeds between 10 and 99 mph with an accuracy of ± 1 mph.

A700-2.3 Electronic Regulatory Signs

The ERS must be designed to give notice of traffic laws or regulations, such as the posted speed limit. ERS used for variable speed limit (VSL) applications must be able to display speed limits from 5-70 mph in 5 mph increments and mimic the physical appearance of a static regulatory speed limit sign as shown in the MUTCD and SHS. ERS for VSL applications shall use black characters on a white background. ERS for VSL applications must log the time and date of any speed limit change to internal non-volatile memory. The log must be able to record a minimum of 1,000 events in a first-in, first-out fashion.

A700-2.3.1 ERS Foreground/Background Colors and Display Types

The dynamic display of ERS used for variable speed limit applications must display black characters on a white background. Display Modules for all ERS shall have a minimum 2-inch contrasting margin around digits, text, or graphics. Type 1 ERS must utilize LED technology for the dynamic display. Type 2 ERS must utilize scrolling-film technology for the dynamic display.

A700-2.3.1.1 LED and Pixel Specifications for Type 1 ERS

Type 1 ERS shall meet the LED and Pixel specifications defined in section A700-2.1.3.3-4.

A700-2.3.1.2 Scrolling Film Mechanism for Type 2 ERS

The dynamic display for Type 2 ERS shall utilize scrolling film module comprised of a transparent film with black characters meeting the size and shape requirements shown in the MUTCD and SHS. The transparent film and characters shall move in front of a background panel covered with reflective sheeting identical to that used on the static sign panel. The transparent film must be constructed of material that will not yellow, fade, deform, or otherwise deteriorate over the lifetime of the sign.

A700-2.3.1.3 **ERS Character Size and Font**

Fonts and graphics for Type 1 ERS shall mimic the characteristics of fonts and graphics defined in the MUTCD and SHS. Fonts and graphics for Type 2 ERS shall exactly match the characteristics of fonts and graphics defined in the MUTCD and SHS.

A700-2.3.2 Variable Speed Limit ERS Controller Communications

ERS for variable speed applications shall be equipped with a sign controller that includes a minimum of 1 Ethernet 10/100 Base TX 8P8C port.

A700-2.3.3 Configuration and Management Requirements for Variable Speed Limit ERS

Ensure that ERS for VSL applications can be managed remotely from a TMC or managed locally using a laptop computer. Ensure that the TMC or a laptop computer can be used to remotely reset VSL sign controllers. Ensure that ERS for VSL applications will log and report status, errors, and failures, including data transmission errors, receipt of invalid data, communication failure recoveries, alternating current power failures, power recoveries, display errors, fan and airflow status, temperature status, power supply status, and information on the operational status of the temperature, photocell, airflow, humidity, and LED power supply sensors.

Ensure that the sign controller is addressable through an Ethernet communication network using software that complies with the NTCIP requirements published online by the Florida Department of Transportation Traffic Engineering Research Laboratory at: http://www.dot.state.fl.us/trafficoperations. Ensure that the sign implements any NTCIP standards required to achieve interoperability and interchangeability. Ensure that any additional objects implemented by the software do not interfere with the standard operation of any mandatory objects. ERS must be compatible with the FDOT SunGuide® software.

A700-2.3.4 Blank-Out Signs

ERS designed for BOS applications shall have a black exterior finish (Federal Standard 595A-37038) with a reflectance value not exceeding 25 percent. BOS shall include a visor.

A700-2.3.5 ERS Battery Backup System

AC powered signs shall include a battery backup system that maintains full operation of the sign for a minimum of 2 hours in the event of utility power loss. Operation on battery backup shall have no visible effect on the appearance of the display.

A700-2.4 Electronic Speed Feedback Signs

The ESFS must be designed to alert road users of their speed as they approach the sign.

A700-2.4.1 ESFS Background/Foreground Colors

The ESFS display background must be flat black (Federal Standard 595A-37038) with a reflectance value not exceeding 25 percent. ESFS must utilize amber LEDs with a peak wavelength of 590 nanometers. ESFS shall have a minimum 1-inch contrasting margin around illuminated characters or graphics.

A700-2.4.2 Speed Detector

The ESFS shall be programmable for the posted speed limit and the maximum speed to display**.** When the detected speed exceeds the maximum programmed speed (high speed cut-off) threshold, the display will automatically blank. Alternately, the display may show an alert message such as “SLOW DOWN” when speeds above the maximum programmed speed threshold are detected.

The ESFS shall detect when the posted speed is exceeded by 1 mph and then activate the alert. When the alert is activated, the display shall flash at a rate of 50 to 60 cycles per minute. When no advancing traffic is detected, the display shall be blank. The speed detector shall not activate alerts or display speeds for vehicles outside the display’s cone of vision.

The speed detector shall not be affected by normal radio transmissions. The ESFS shall meet the requirements of FCC Part 90. The ESFS shall not require an FCC operating license. The speed detector shall operate on 10.8 to 16.6 VDC. The ESFS shall monitor and display the speed of approaching traffic only. The ESFS detector shall be able to accurately detect and determine the speed of approaching vehicles. The ESFS shall be able to detect a motorized vehicle 1,000 feet in advance of the sign. The ESFS shall be capable of measuring speeds between 10 and 99 mph with an accuracy of ± 1 mph.

A700-3 Environmental Requirements

The electronic display shall meet the environmental requirements in Section A615. The display shall be designed and constructed in a manner that prohibits fogging, frost, or condensation from forming within the dynamic portion of the sign.

A700-4 Warranty

Ensure that the EDS systems and equipment furnished have a manufacturer's warranty covering defects in assembly, fabrication, and materials for a minimum of 3 years.

MINIMUM SPECIFICATIONS
FOR
TRAFFIC CONTROL SIGNALS AND DEVICES
July 2010

APPENDIX A & B
(Figures)

APPENDIX A

FIGURES

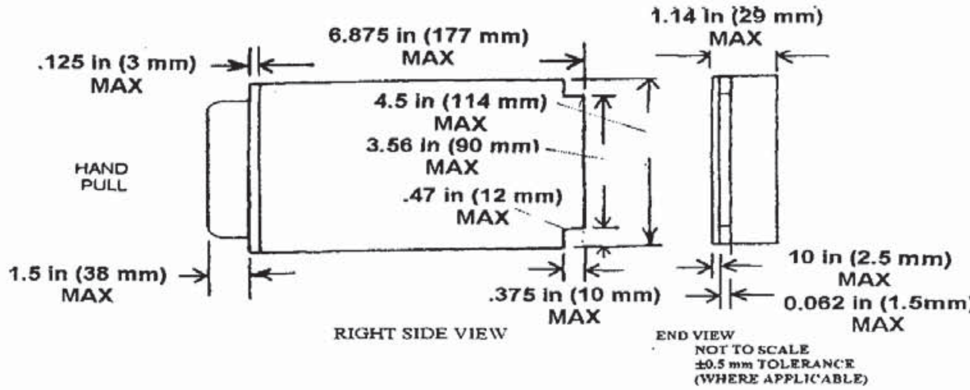


FIGURE A660-1 TWO-CHANNEL CARD RACK UNIT

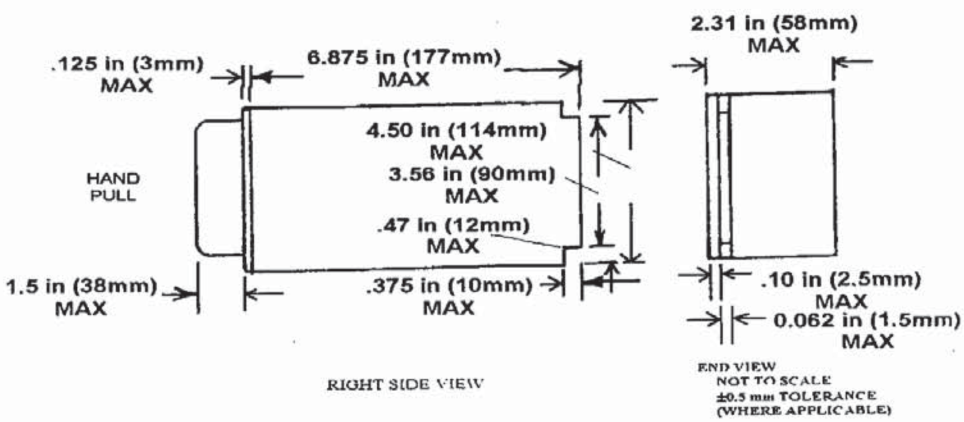


FIGURE A660-2 FOUR-CHANNEL CARD RACK UNIT

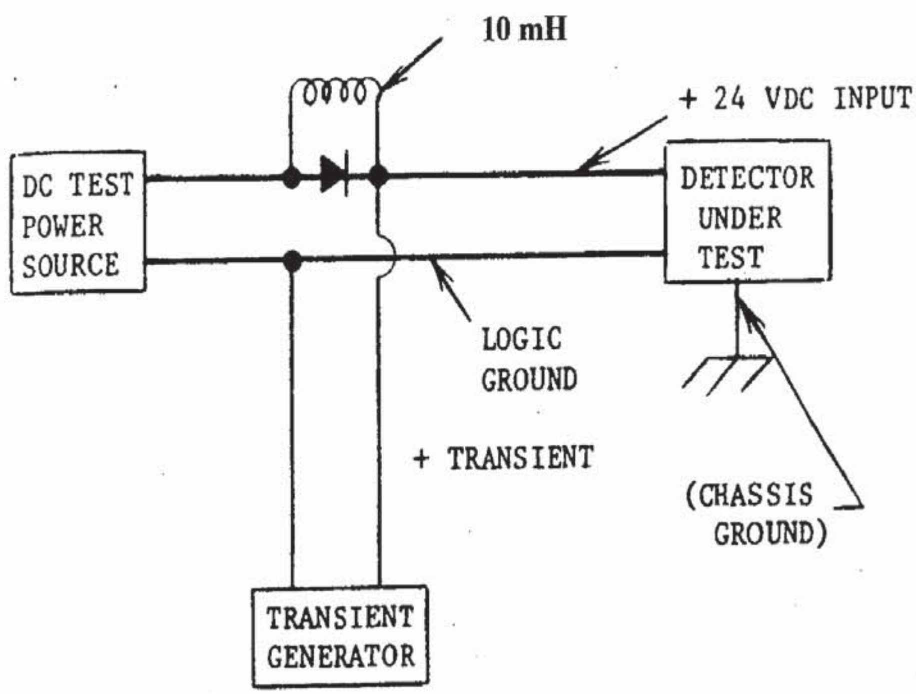
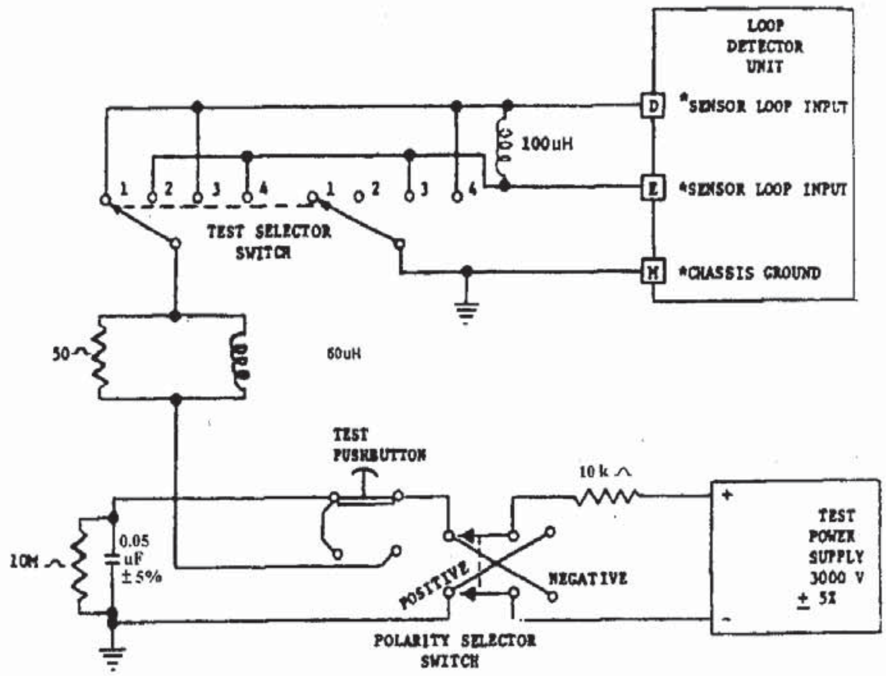


FIGURE A660-4 TEST CONFIGURATION FOR TYPES 9 THROUGH 12 DETECTOR UNITS

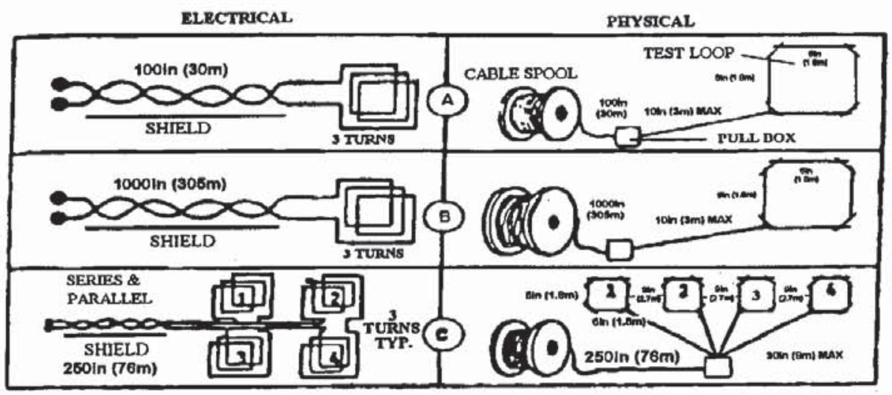


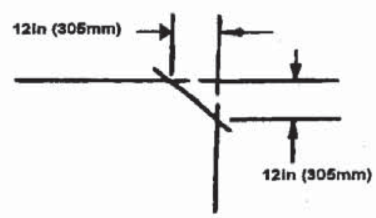
Test Number+	*Test Selector Position*	*Polarity Selector*	*Tested Inputs**
1	1	Positive	D To H
2	2	Positive	E To H
3	3	Positive	D To E
4	4	Positive	E To D
5	1	Negative	D To H
6	2	Negative	E To H
7	3	Negative	D To E
8	4	Negative	E To D

+ The test pushbutton shall be activated for at least 4 seconds for each transient pulse for the eight tests.

*The pin designations shown are for a single channel detector. Similar tests shall be performed on all channels of a multichannel detector.

FIGURE A660-5 LOOP INPUT TERMINAL TRANSIENT TESTS





CHAMFER DETAIL

CONSTRUCTION-Loop dimension tolerance shall be 50 mm. Connections shall be soldered and water-proofed. Loops shall be installed in an nonreinforced pavement and located at least 0.9 m from any conductive material. Lead-in cable shall be spooled. Loop leads shall exit at one corner of the loop structure. All loop corners shall be chamfered 305 mm.

LOOP WIRE- Each loop shall be three turns of AWG #14 cross-linked polyethylene insulated, stranded copper wire, such as Belden 35614. Loop inductance shall be between 60-80 μH.

LEAD-IN WIRE- The lead-in wire shall be AWG #14 twisted pair, aluminum polyethlene insulation, vinyl jacket, inductance between 20 μH and 24 μH per 30 mm such as Belden 8720. For standardized test purposes, the shield shall be insulated from ground.

SAWSLOT- The conductors shall be placed at the bottom of a 40 mm ± 5 mm wide sawslot. Pavement sawslot shall be filled with a suitable epoxy or equivalent sealent. Hold down material shall be used to ensure the loop wire is at the bottom of the slot.

FIGURE A660-6 PERFORMANCE TEST LOOP CONFIGURATIONS

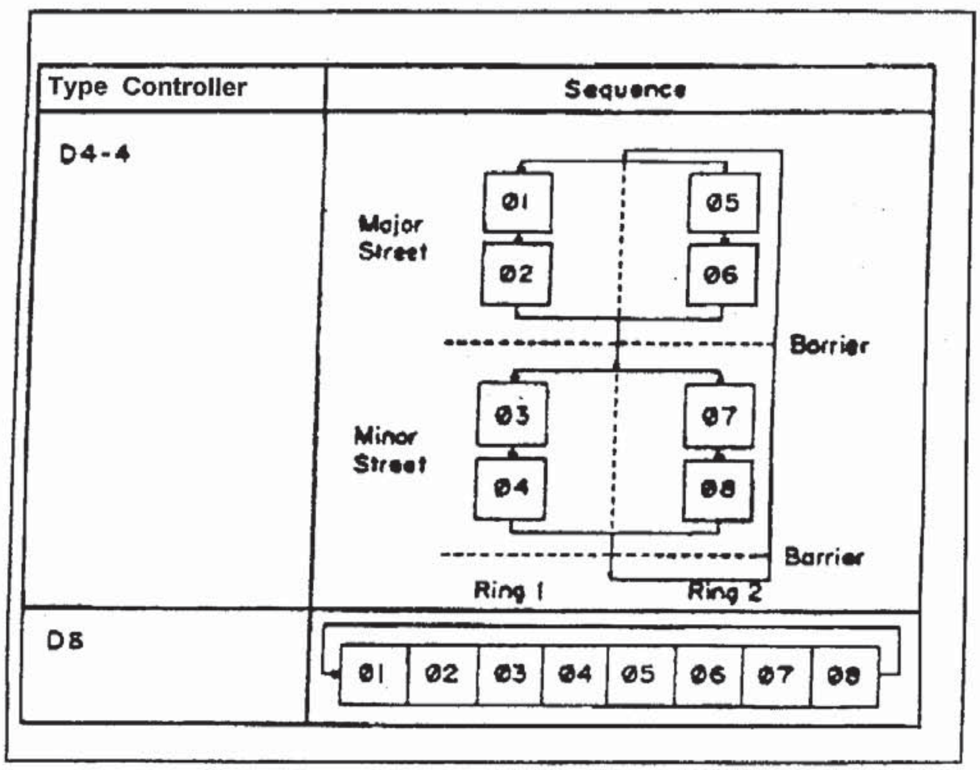
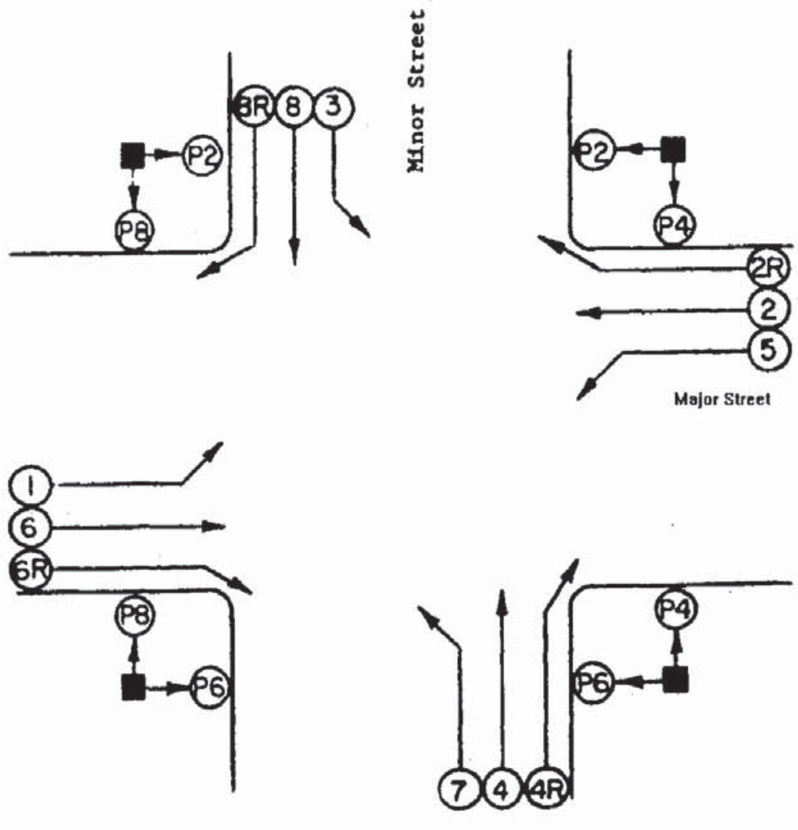


FIGURE A671-1 PREFERENTIAL SEQUENCE



Legend

(X) — Vehicle movement number and Signal head number.

(PX) — Pedestrian movement number and signal head number.

Note

(XR) — Used only when shown in S.O.P..

FIGURE A676-1 SIGNALIZATION MOVEMENT ASSIGNMENT

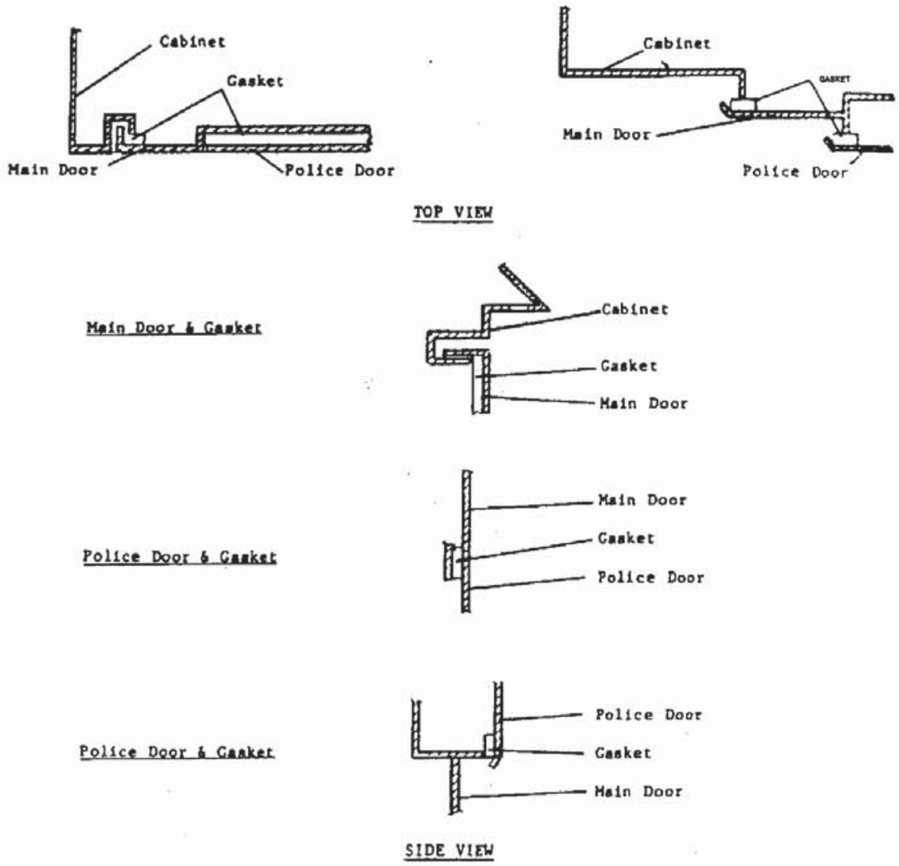


FIGURE A676-2 TYPICAL GASKET PLACEMENT

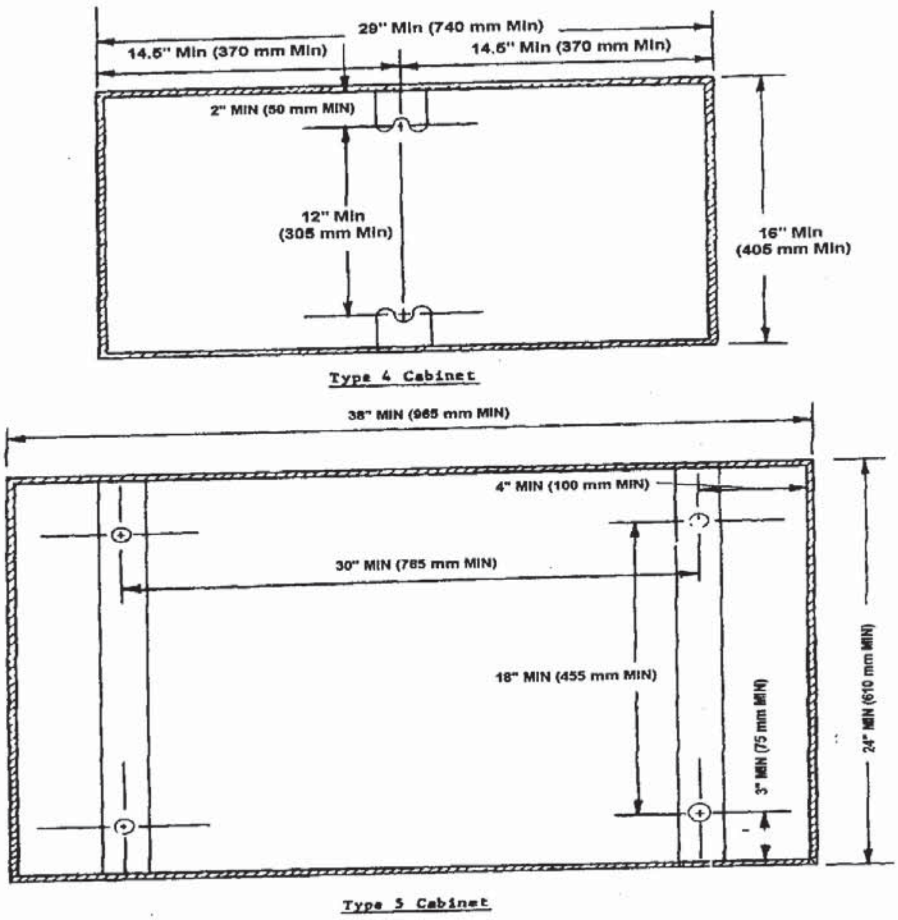


FIGURE A676-3 BASE MOUNTED CABINET BOTTOM DETAIL

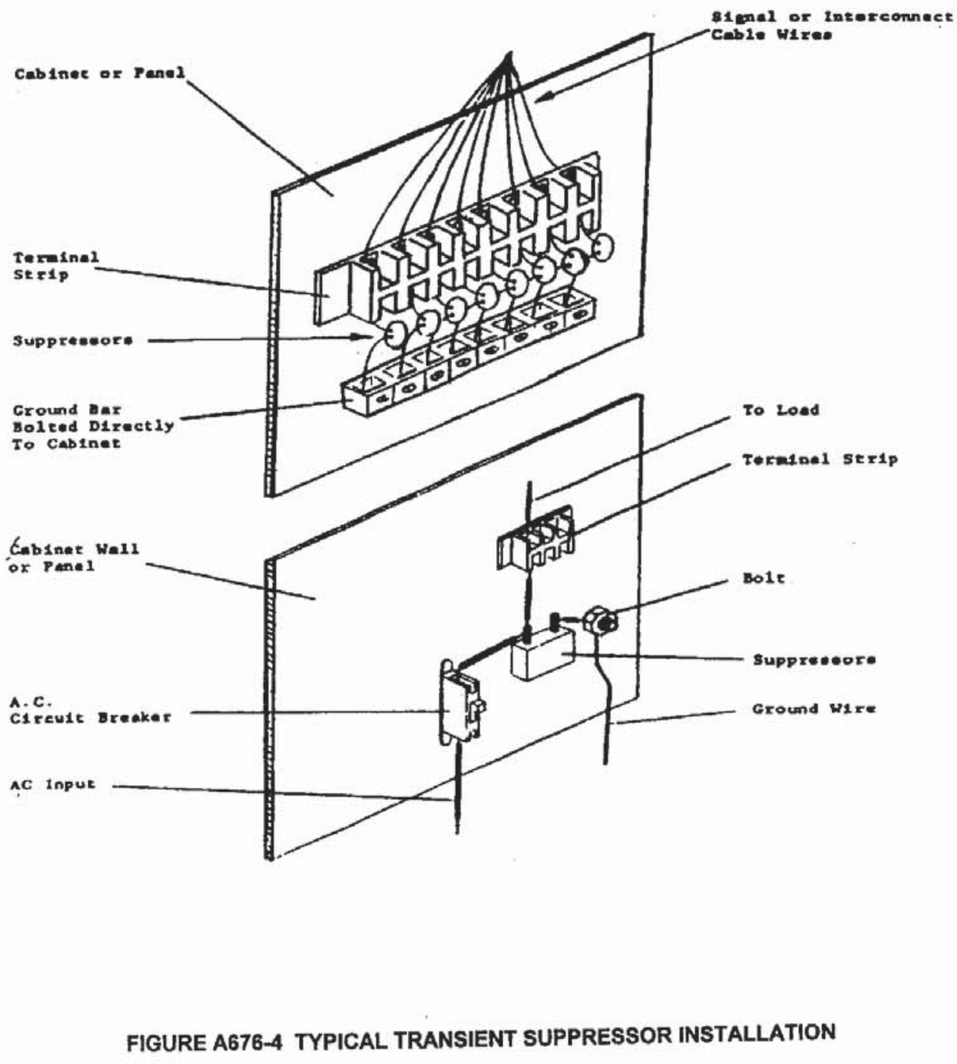


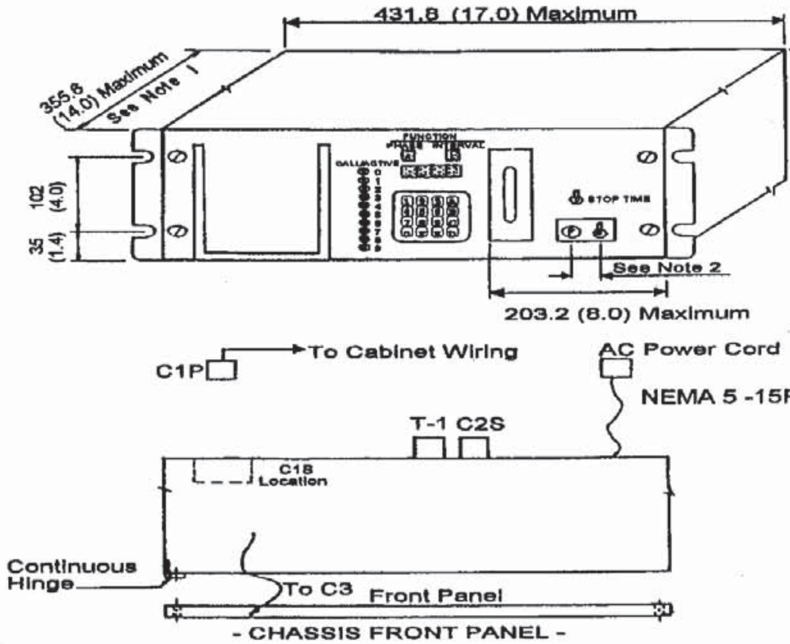
FIGURE A676-4 TYPICAL TRANSIENT SUPPRESSOR INSTALLATION

APPENDIX B

FIGURES
(TYPE 170 CONTROLLER CABINET)

FIGURE 671-3.1

MODEL 170E CONTROLLER UNIT DETAILS

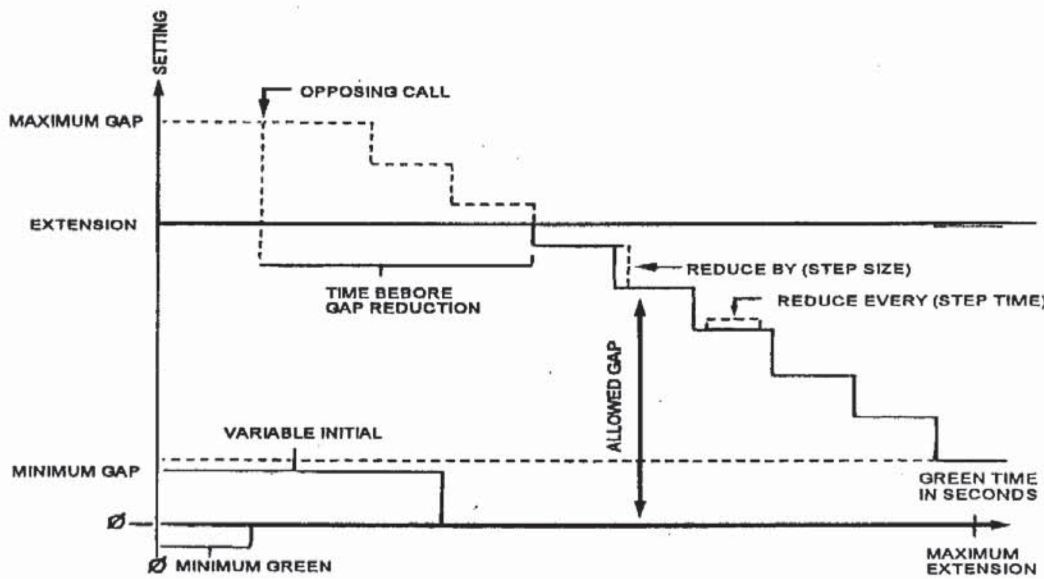


Notes:

1. Connector CIS shall be mounted on the right rear of the chassis. The 355.6 mm (14.0 inches) depth and 177.8 mm (7.0 inches) height maximum dimensions shall include the male connector CIP with "T" handle and T1 & C2S connectors.
2. The fuse holder and ON/OFF switch shall be a minimum of 25.0 (1.0 inch) enter to center.
3. All dimensions are shown in millimeters (inches).

Figure 671-11.2

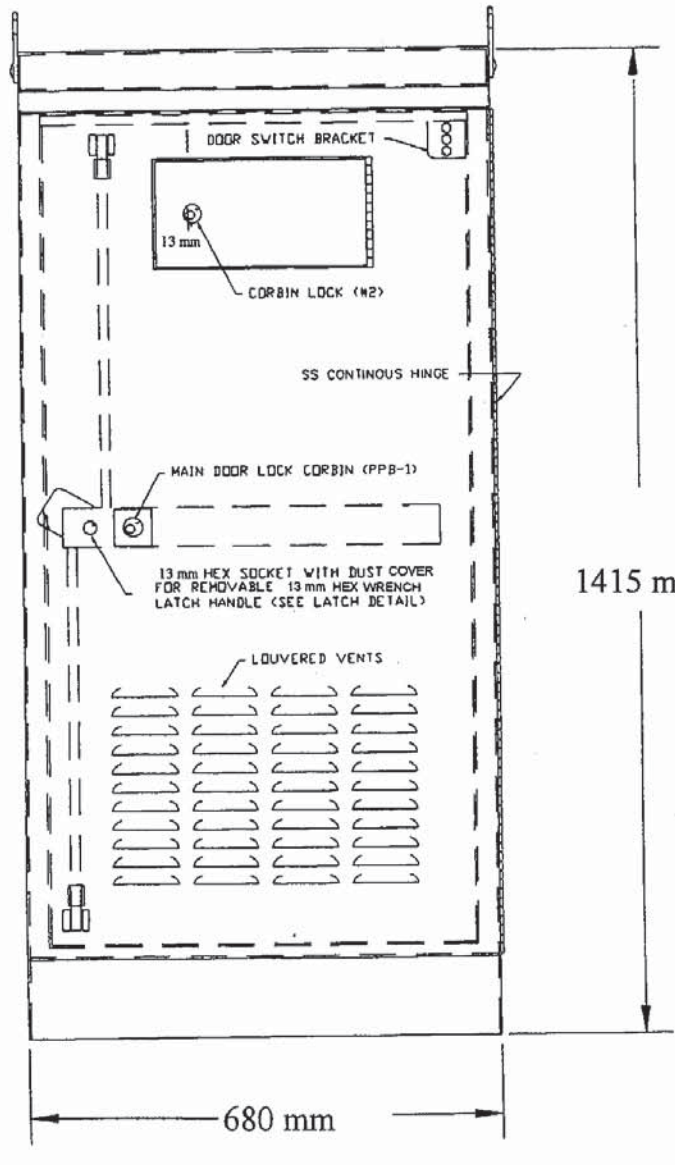
VOLUME DENSITY DEFINITIONS



GREEN INTERVAL TIMING WITH VOLUME DENSITY

FIGURE 676- 1

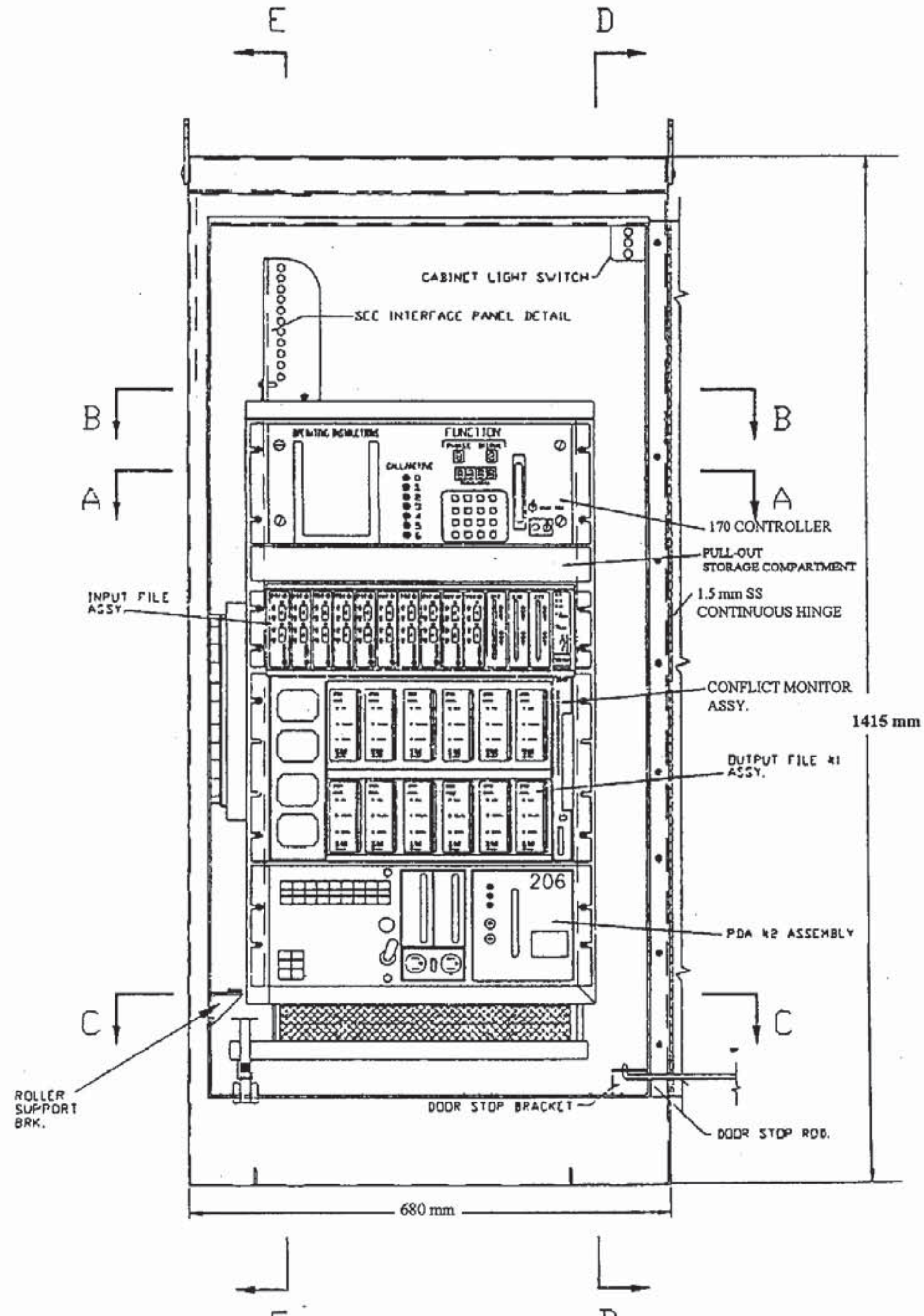
CABINET FRONT VIEW



FRONT VIEW 552AT

FIGURE 676-2

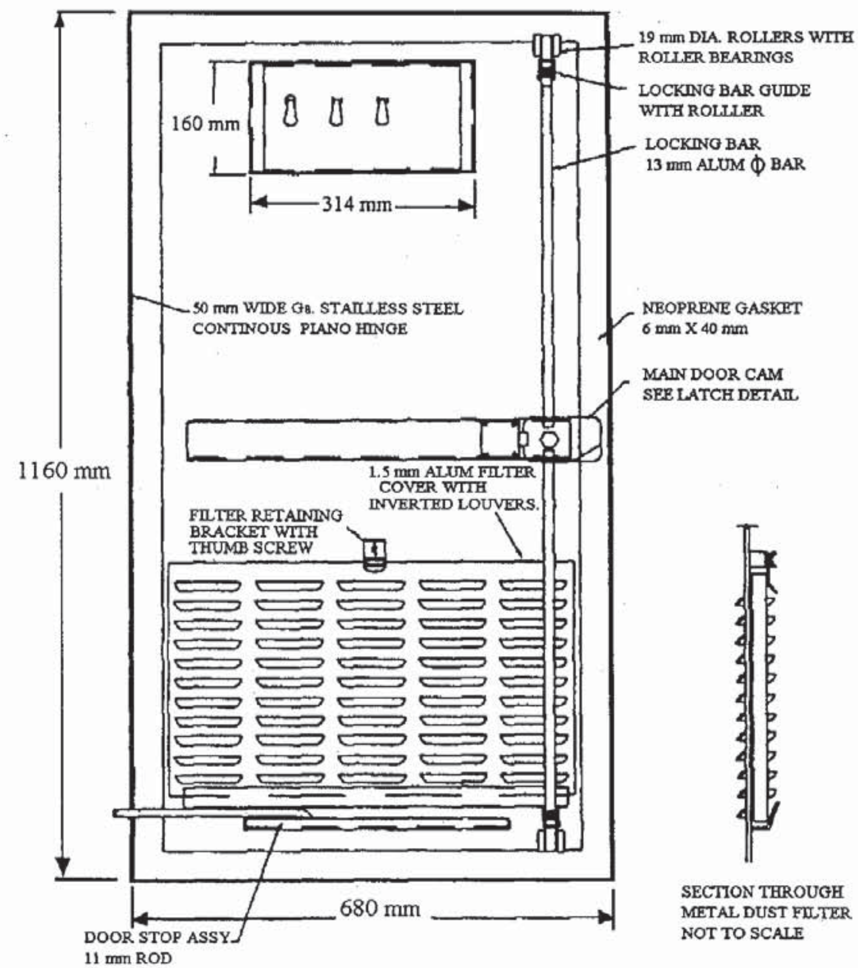
CABINET INTERIOR FRONT VIEW



552AT
INTERIOR OF FRONT VIEW

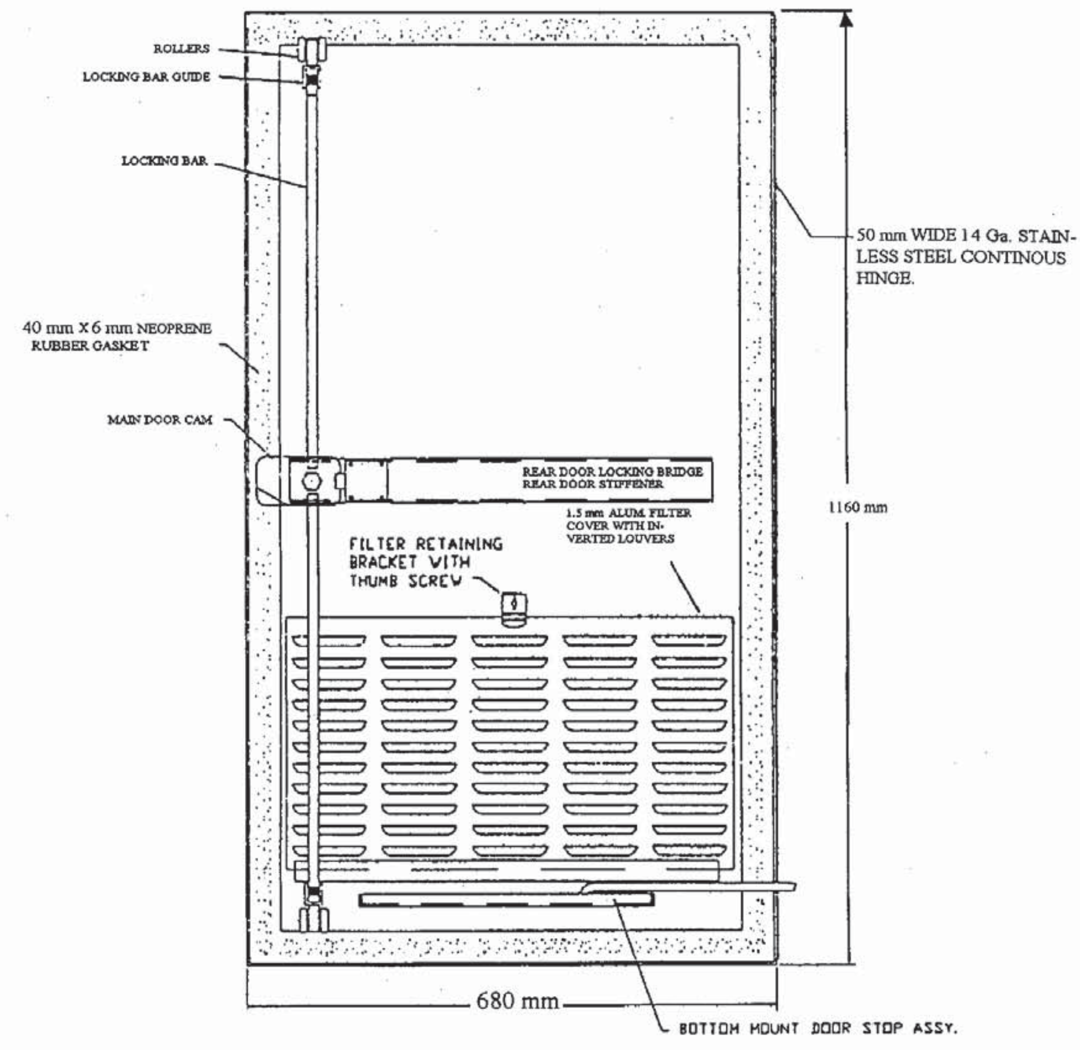
FIGURE 676-3

INTERIOR VIEW OF FRONT CABINET DOOR



INTERIOR VIEW OF FRONT CABINET DOOR
552AT

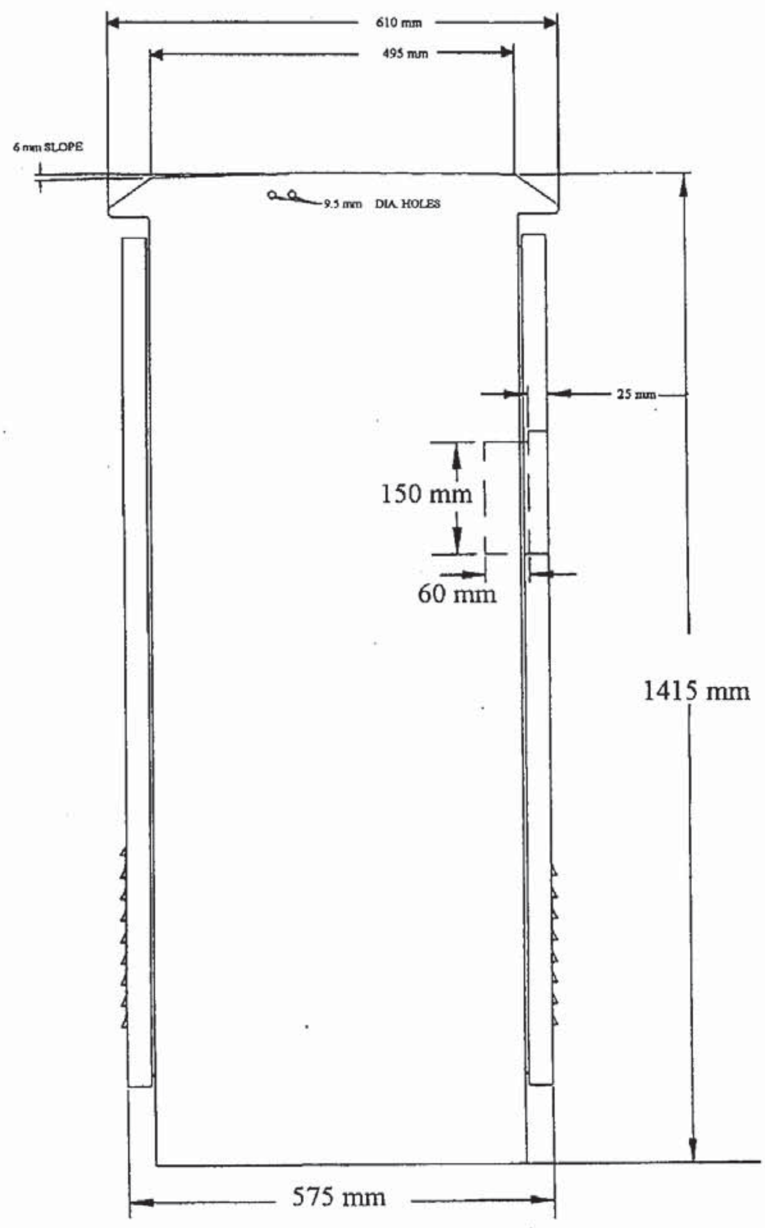
FIGURE 676-4
INTERIOR CABINET REAR DOOR VIEW



INTERIOR VIEW OF REAR CABINET DOOR
552AT

FIGURE 676- 5

CABINET SIDE VIEW

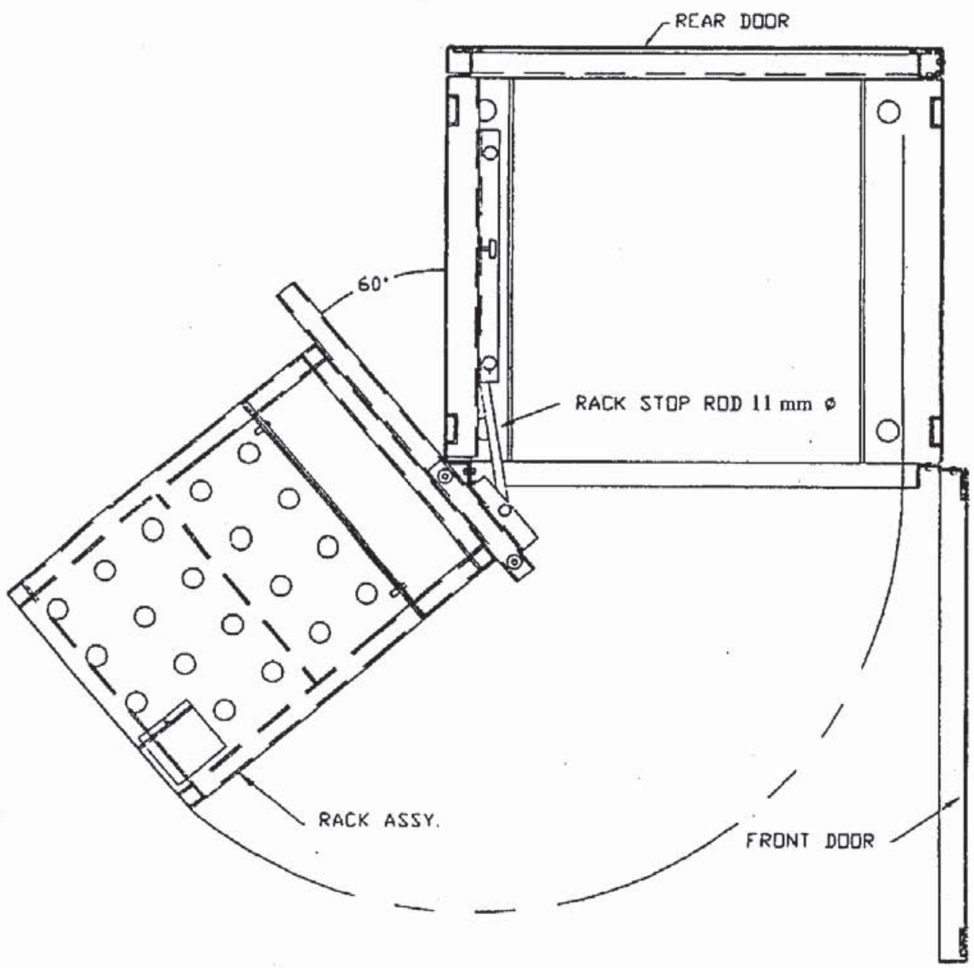


CABINET SIDE VIEW
552AT

FIGURE 676- 6

CROSS SECTION A -- A

CABINET WITH ROTATED RACK ASSEMBLY

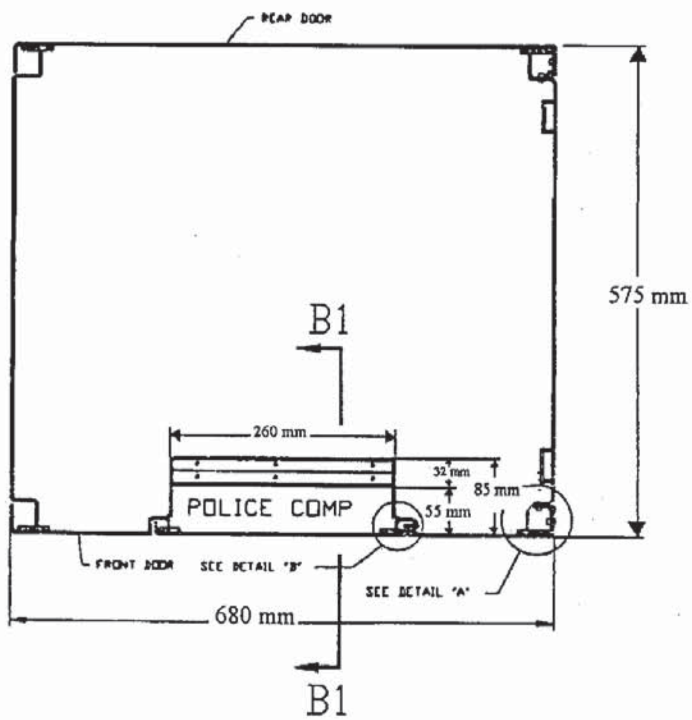


SECTION A-A 552AT

FIGURE 676- 7

CROSS SECTION B -- B

CABINET SHOWING TOP INTERIOR VIEW



SECTION B—B 552AT

FIGURE 676- 8

CROSS SECTION B1 – B1

CABINET WITH POLICE/TECHNICIAN PANELS

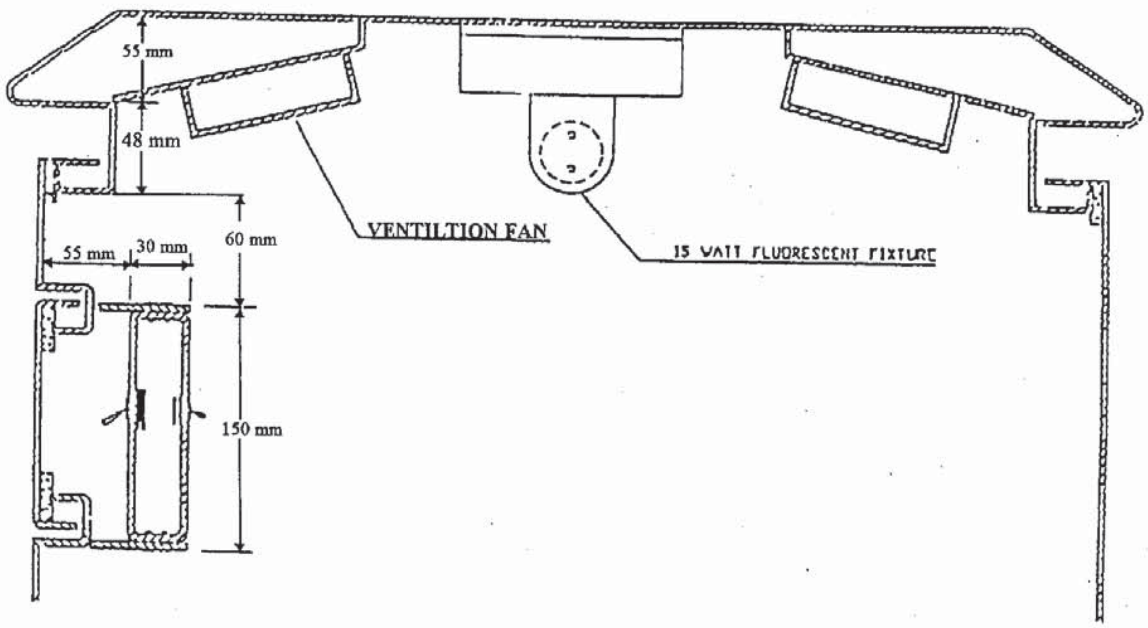


FIGURE 676- 9

DETAILS A & B

DOOR MOUNTING DETAILS

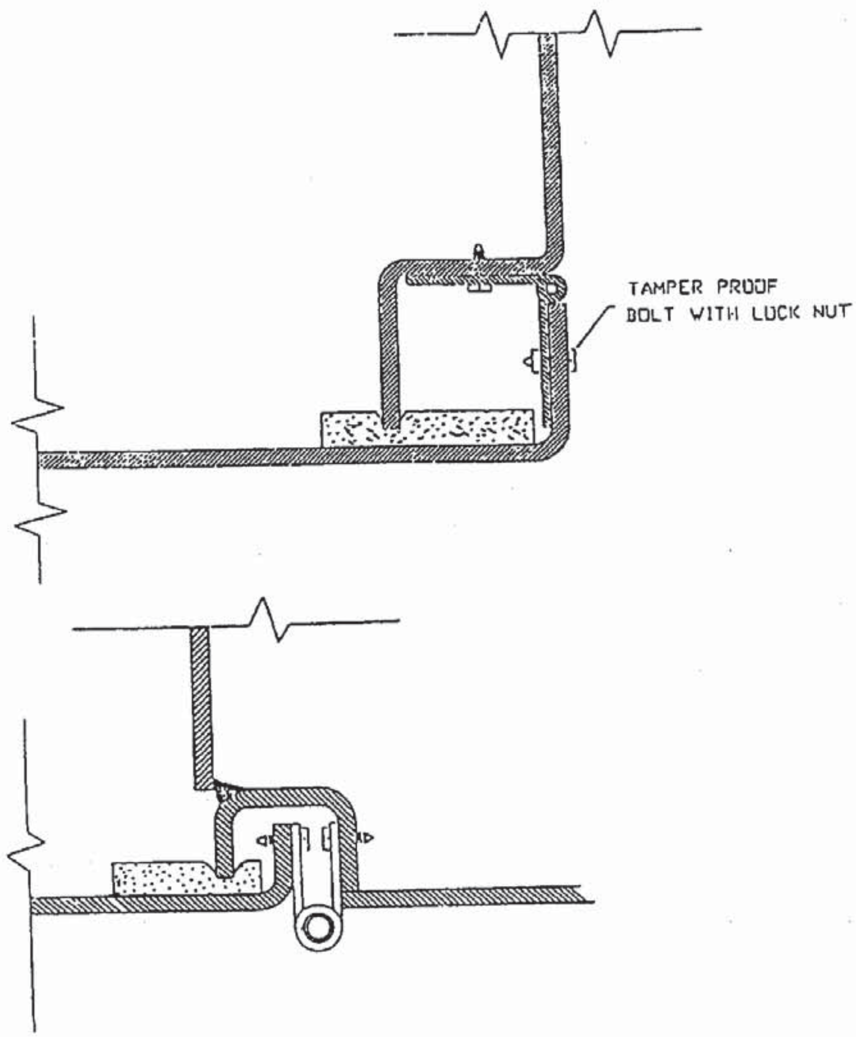


FIGURE 676- 10

CROSS SECTION C -- C

CABINET WITH BOTTOM

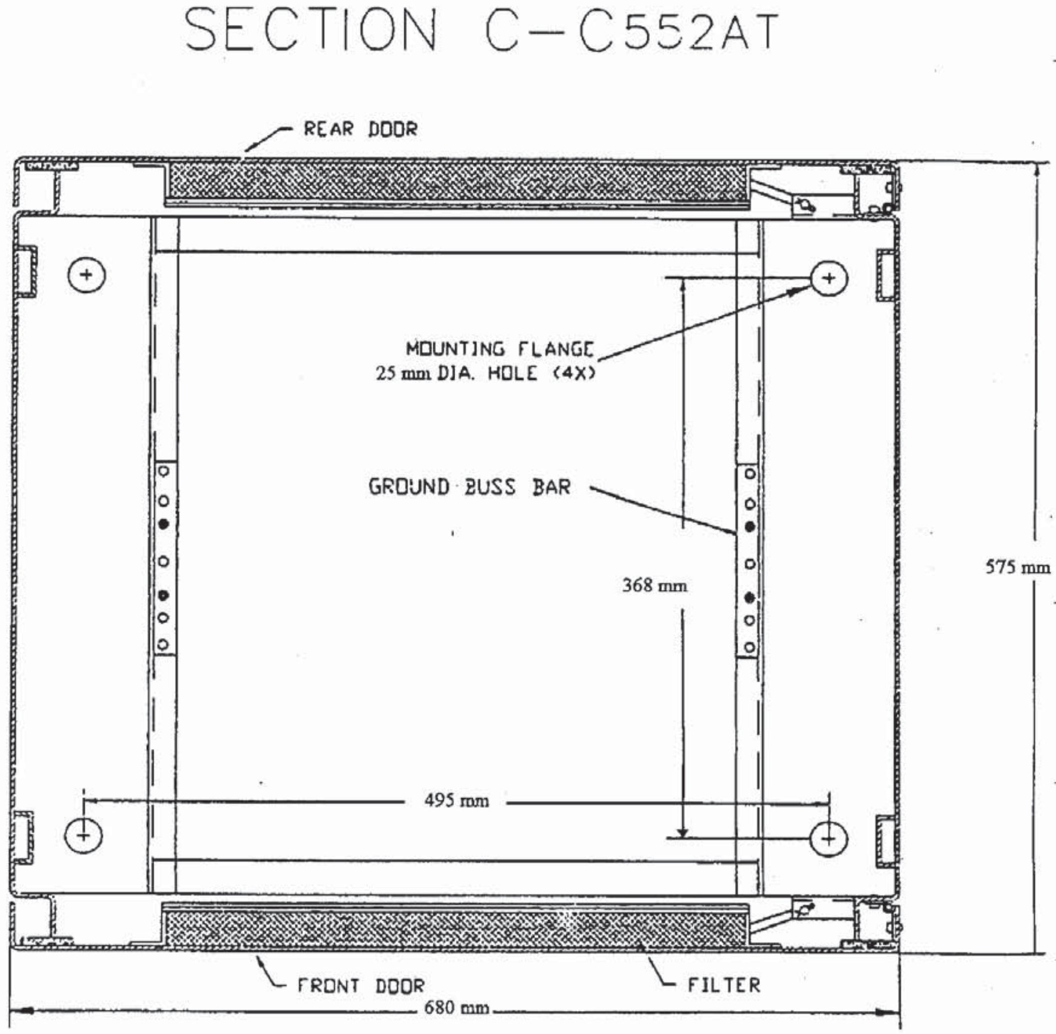
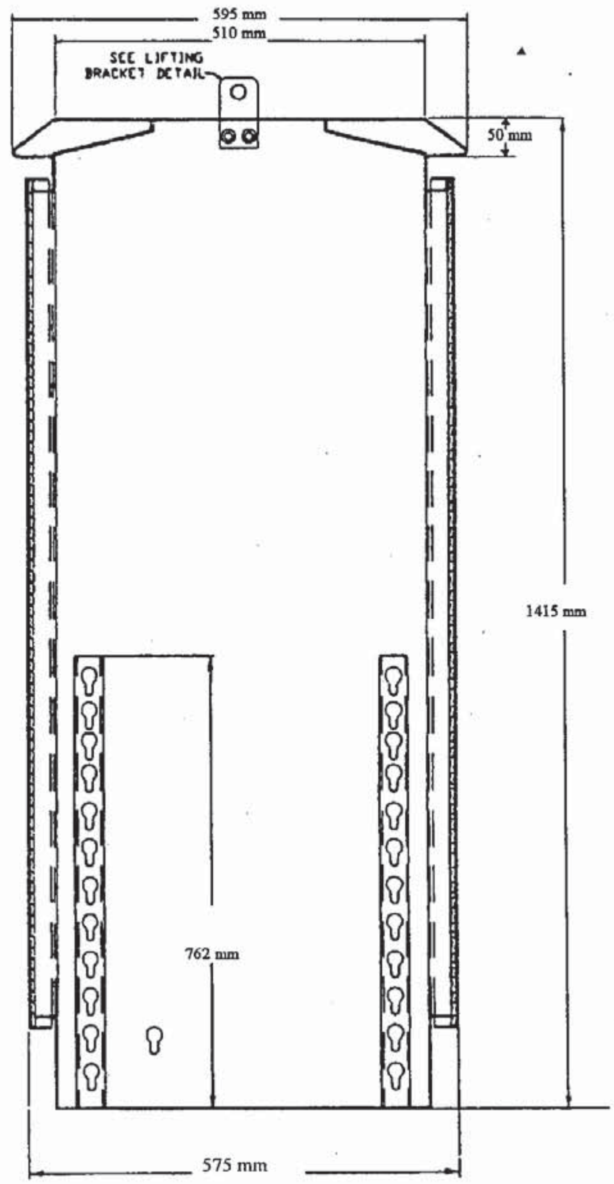


FIGURE 676-11

CROSS SECTION D – D

INTERIOR VIEW OF RIGHT CABINET WALL

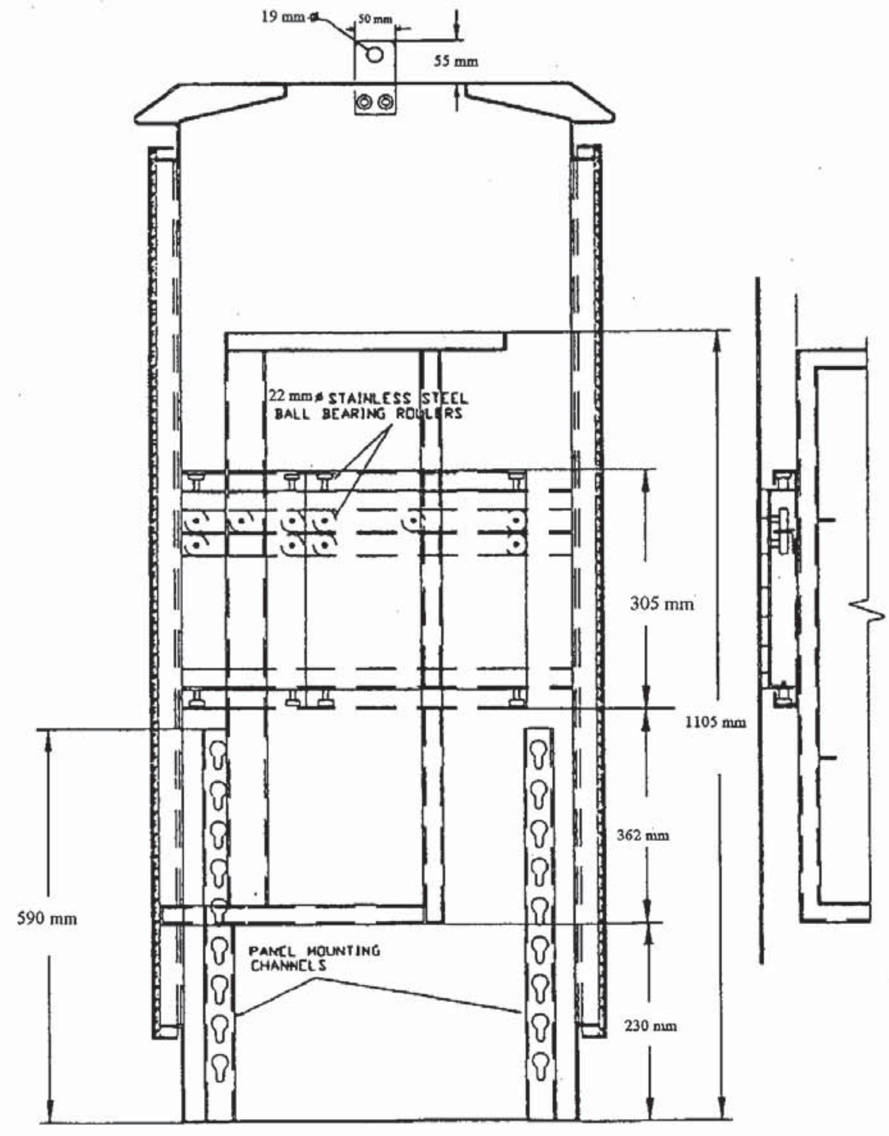


SECTION D–D 552AT

FIGURE 676-12

CROSS SECTION E – E

INTERIOR VIEW OF LEFT CABINET WALL WITH RACK ASSEMBLY BRACKET



SECTION E–E 552AT

FIGURE 676-13

VENT FAN SCHEMATICS

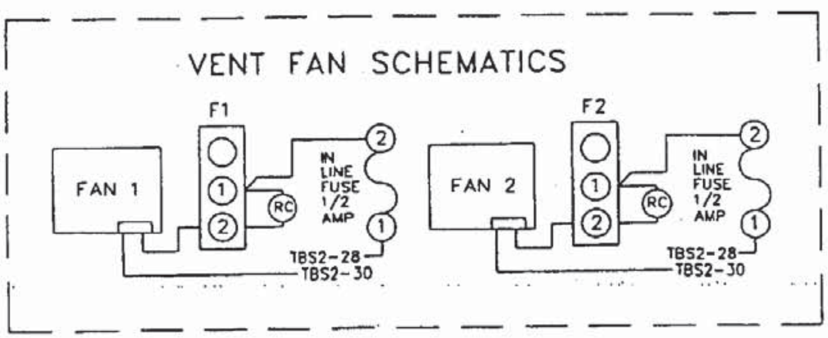
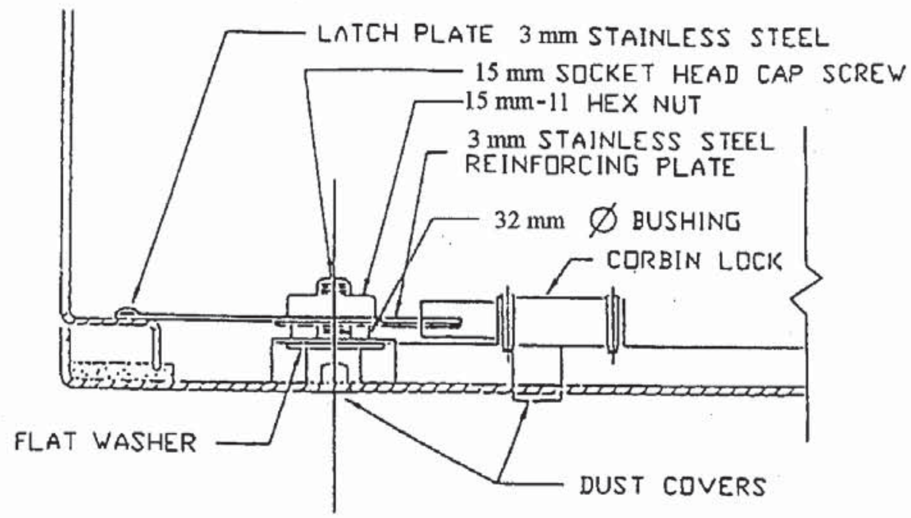
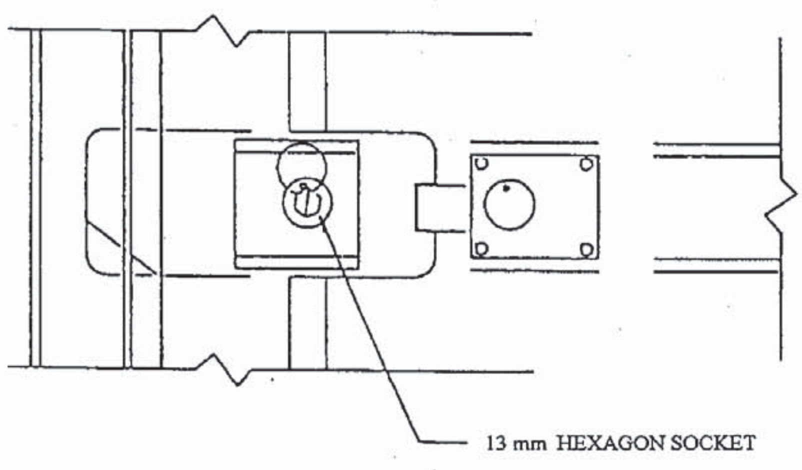


FIGURE 676-14

MAIN DOOR HANDLE SOCKET AND LOCKING BRIDGE DETAILS





NOTES:

1. 3 POINT LATCH; TOP, BOTTOM, AND SIDE @ CENTER POINT.
2. LATCH HANDLE IS A REMOVABLE 13 mm HEXAGON WRENCH 50 mm X 165 mm MIN.
3. HEX WRENCH SHOULD POINT DOWN, PERPENDICULAR TO BASE WHEN INSERTED INTO SOCKET AND SWING AWAY FROM LOCK 90° TO OPEN.
4. LATCH SHALL HAVE A POSITIVE STOP AT FULL OPEN AND CLOSED POSITIONS. BOLT SHALL ENGAGE LATCH FREELY WHEN HANDLE IS TURNED TO LOCK POSITIONS.

FIGURE 676-15

CABINET DOOR STOP BRACKET DETAILS

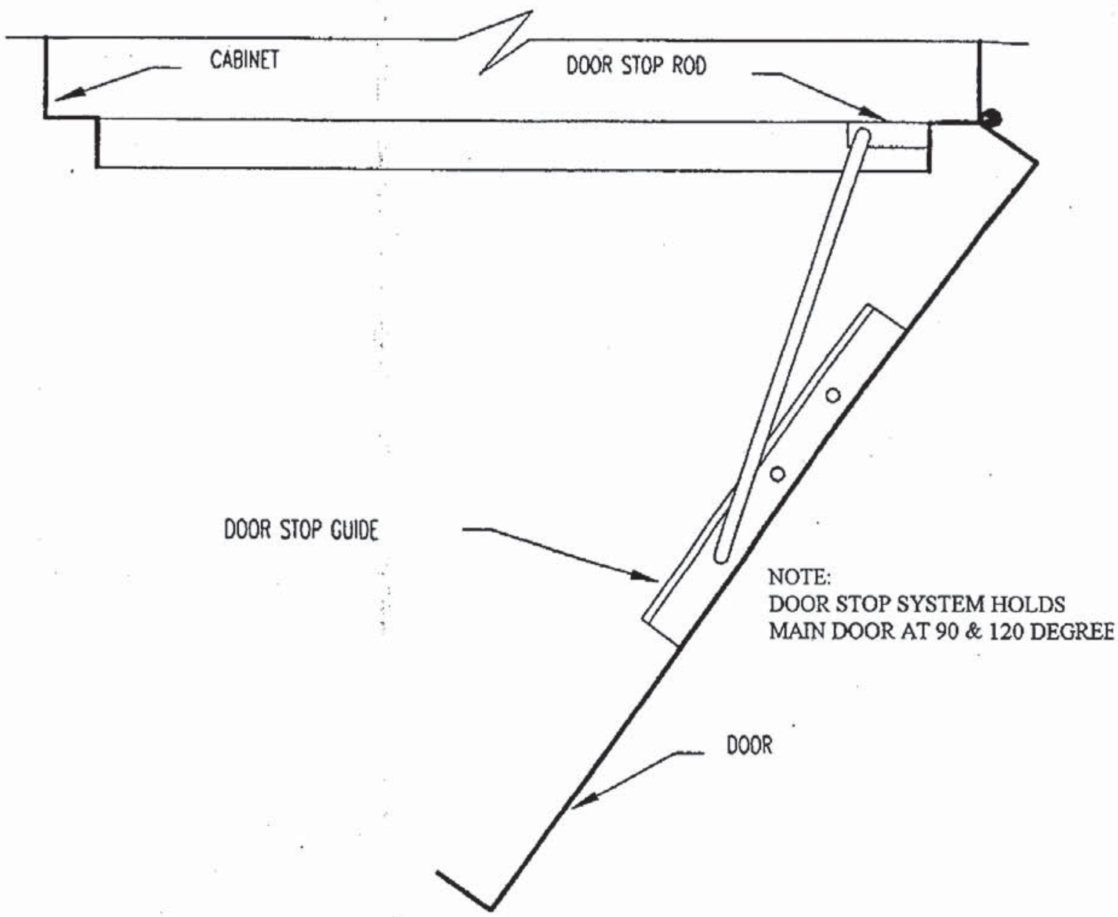


FIGURE 676-16

POLICE PANEL DOOR DETAILS

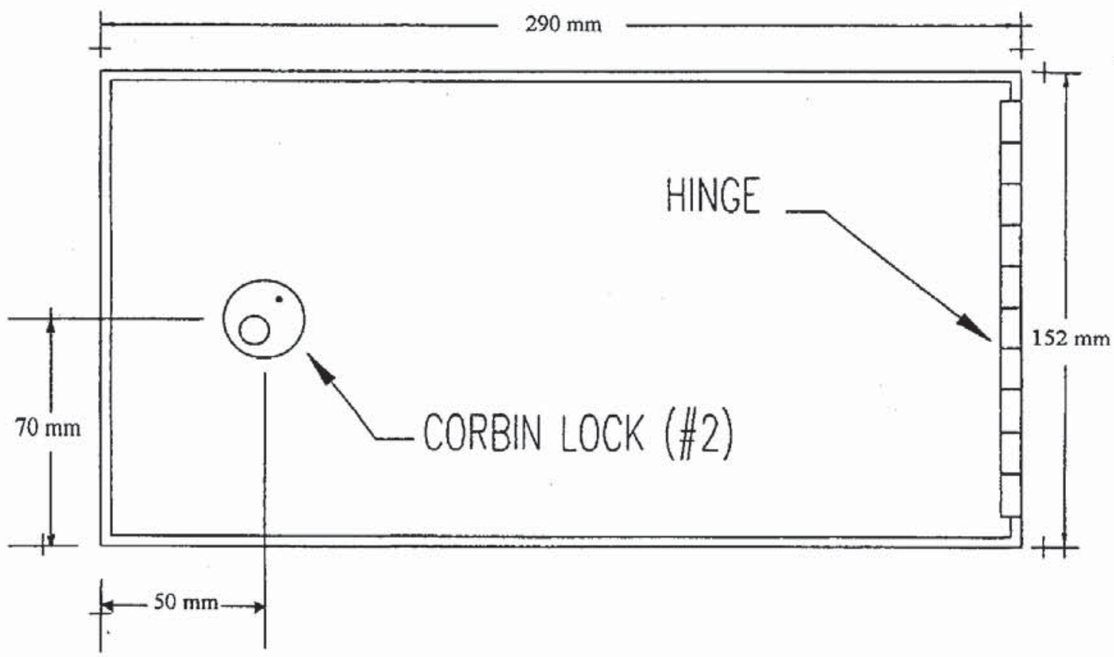


FIGURE 676-17

POLICE PANEL DETAIL

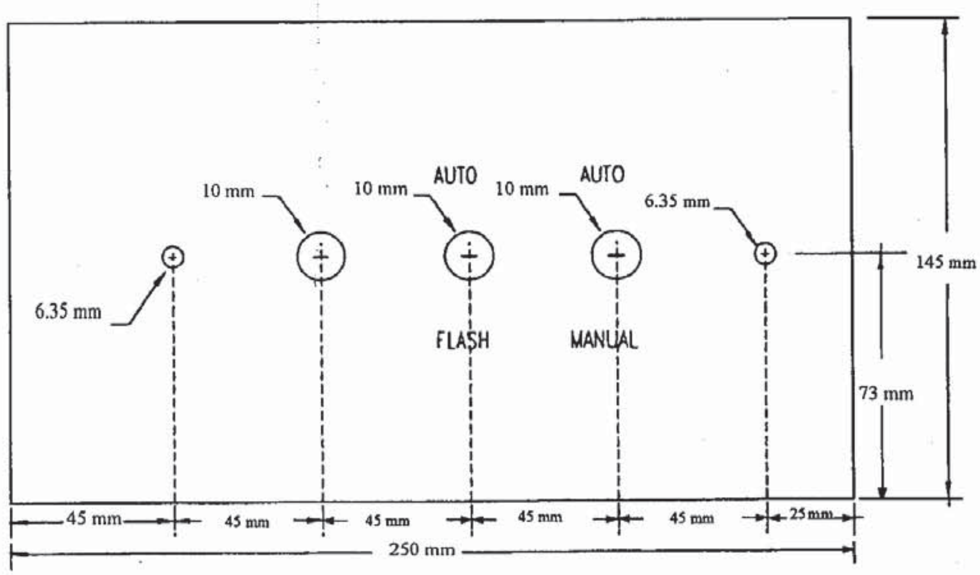


FIGURE 676-18

POLICE PANEL SWITCHES DETAIL

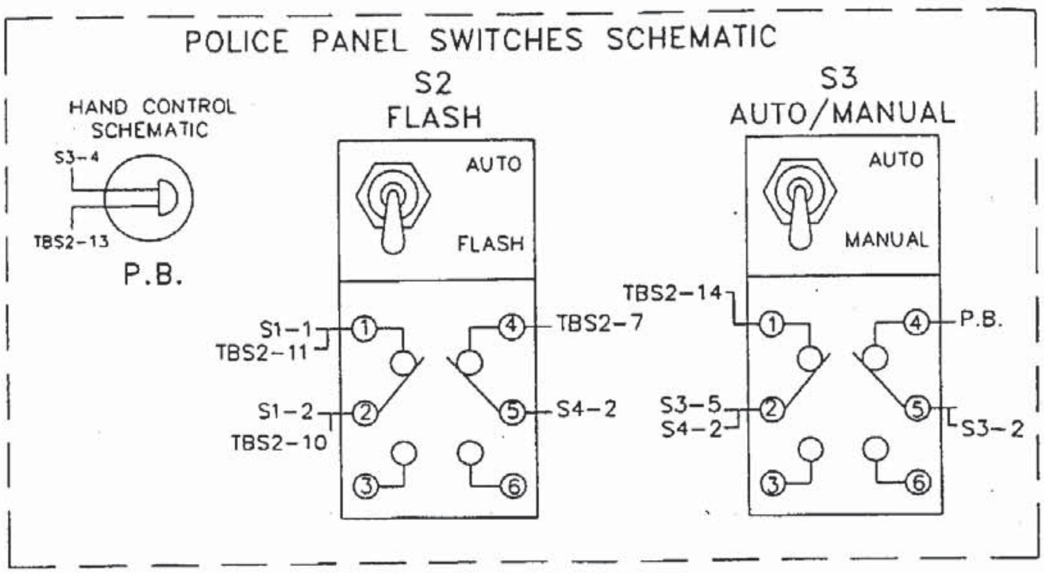


FIGURE 676-19

TECHNICIAN SERVICE PANEL DETAIL

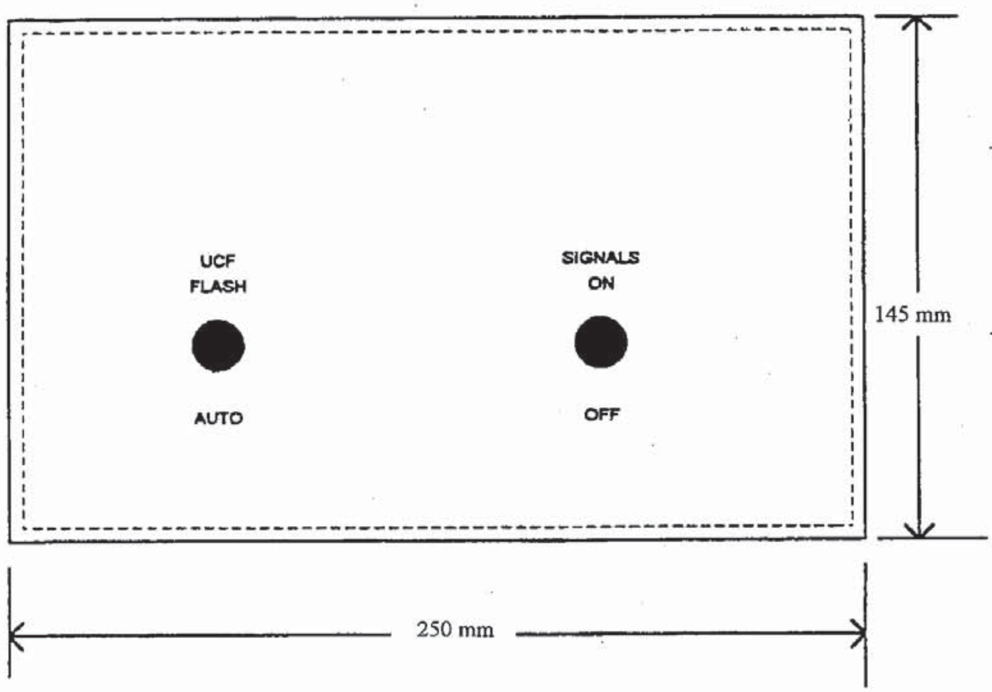


FIGURE 676-20

TECHNICIAN SERVICE PANEL SWITCH SCHEMATIC

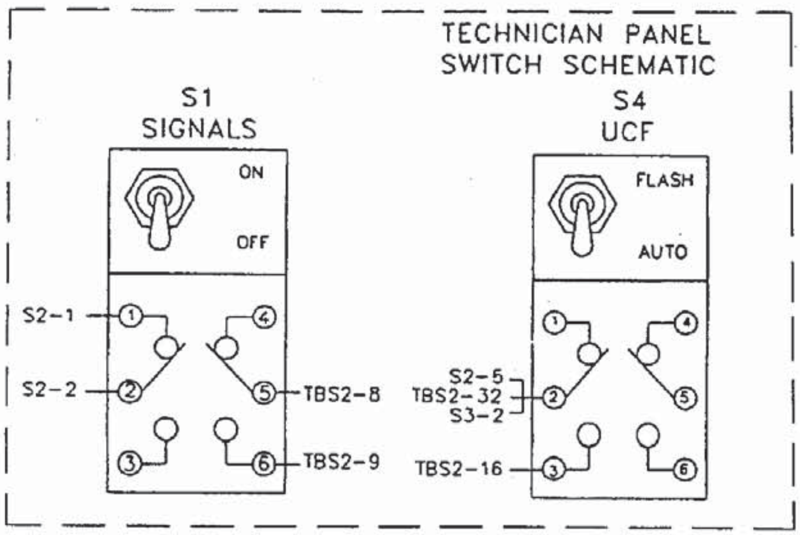
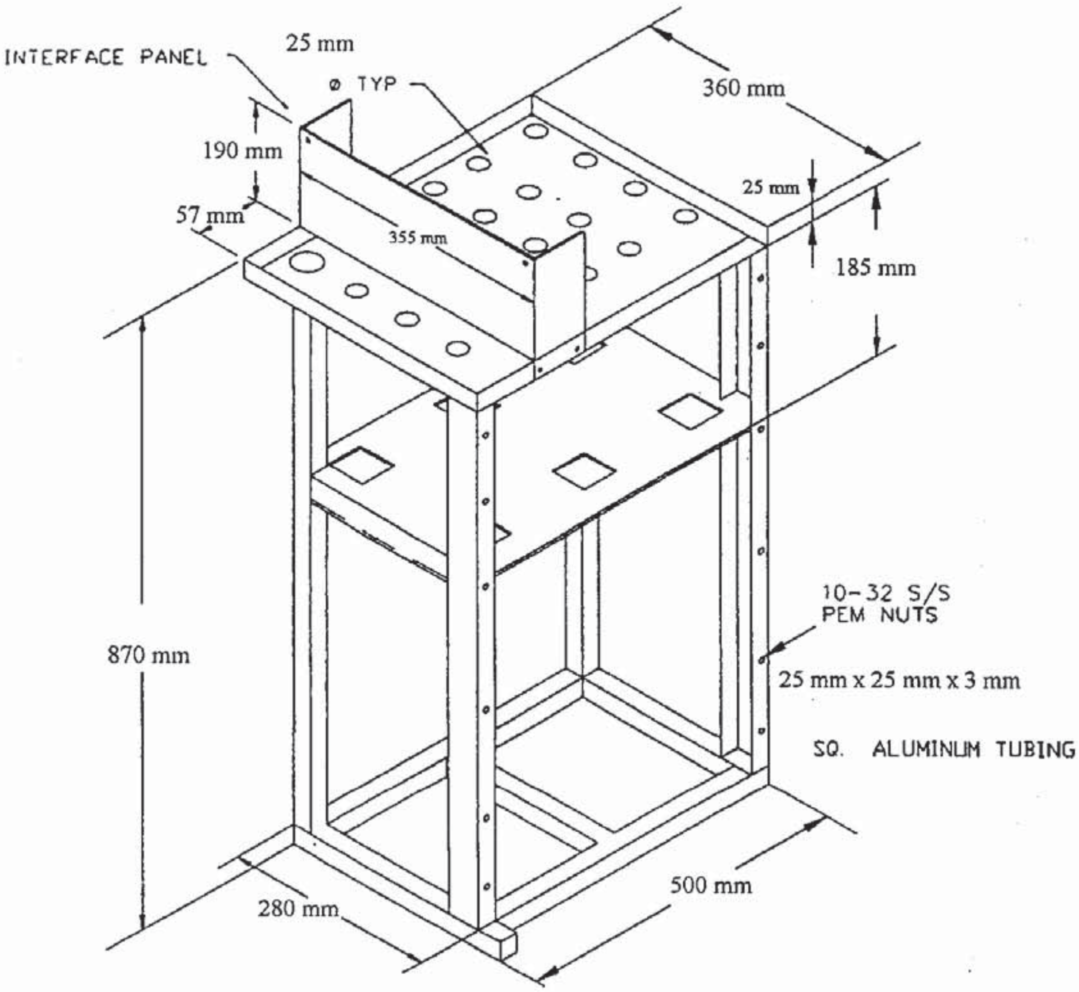


FIGURE 676-21

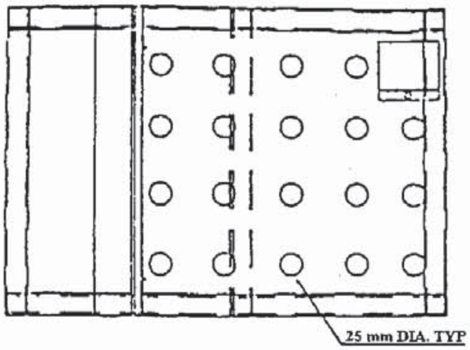
ISOMETRIC VIEW OF RACK ASSEMBLY



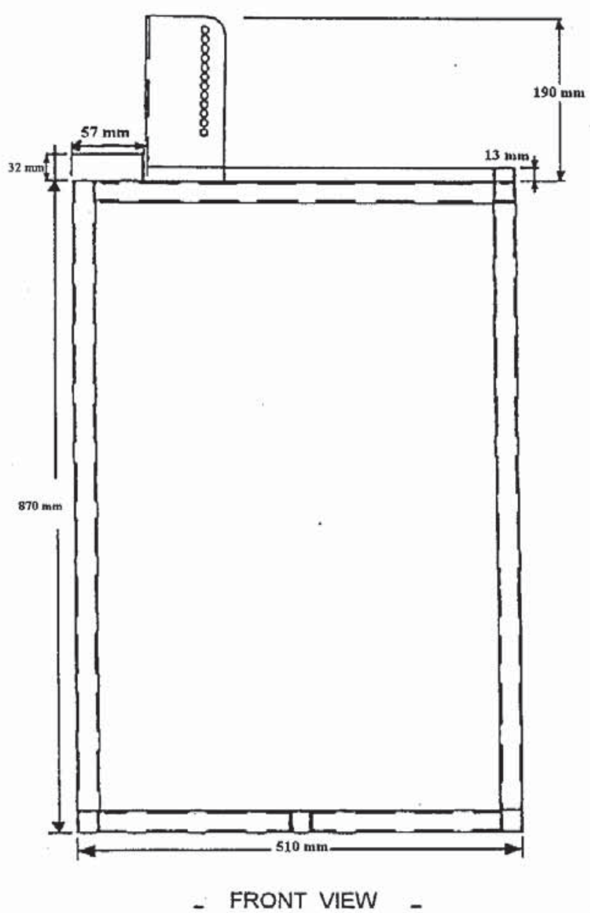
ISOMETRIC VIEW OF RACK ASSEMBLY
552A

FIGURE 676-22

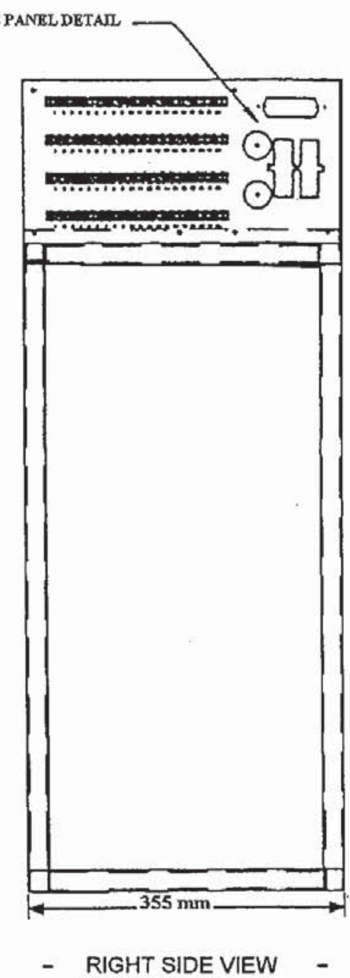
ORTHOGRAPHIC VIEW OF RACK ASSEMBLY



- TOP VIEW -



- FRONT VIEW -



- RIGHT SIDE VIEW -

FIGURE 676-23

CABINET-RACK ASSEMBLY EQUIPMENT ARRANGEMENT

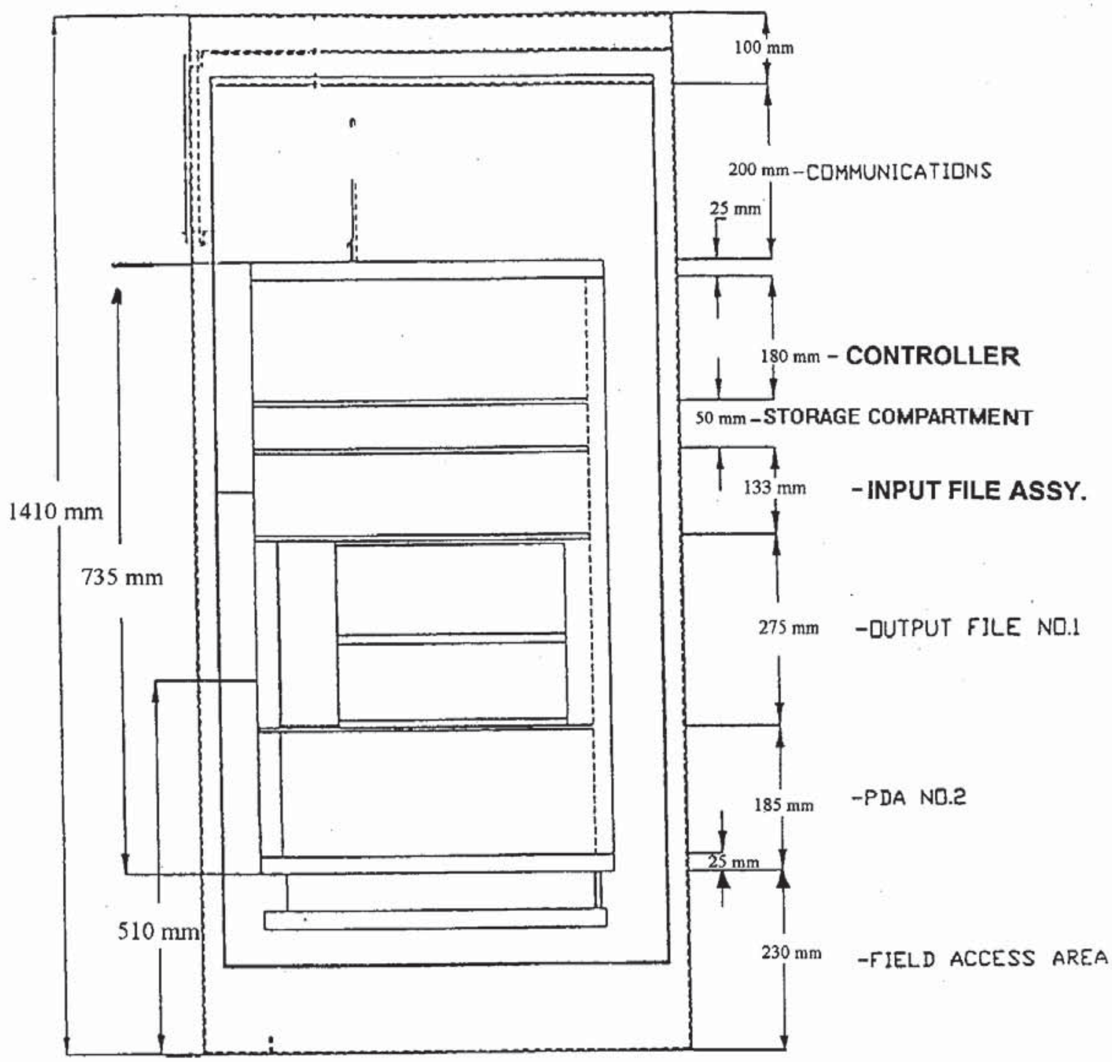


FIGURE 676-24

STORAGE COMPARTMENT BOX DETAIL

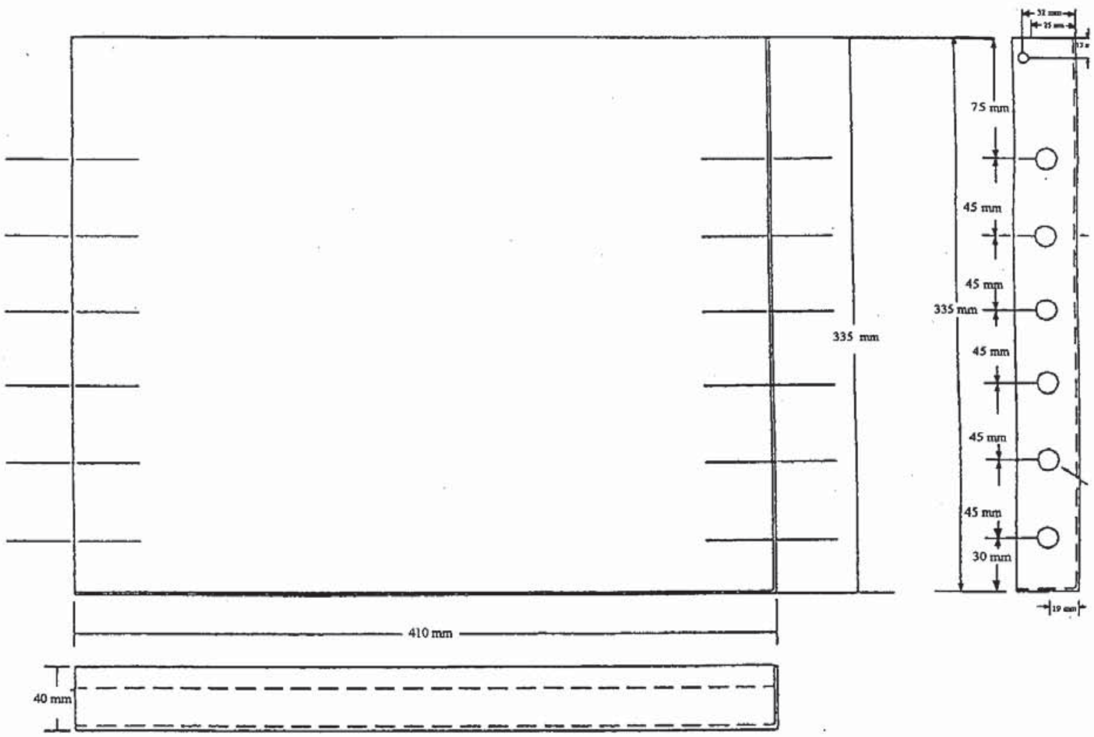


FIGURE 676-25

EXPLODED VIEW OF PULL-OUT STORAGE COMPARTMENT

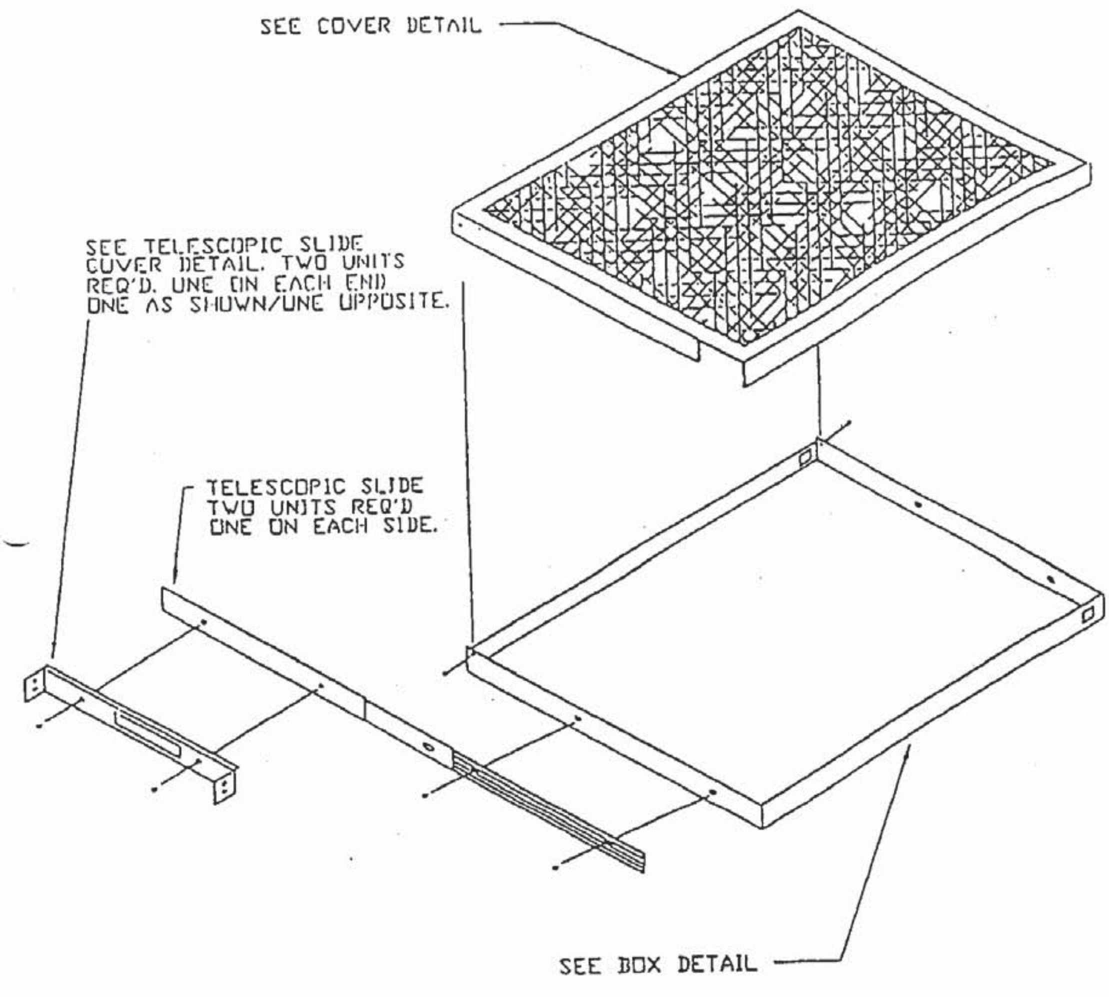


FIGURE 676-26
STORAGE COMPARTMENT TELESCOPING SLIDE AND COVER DETAIL

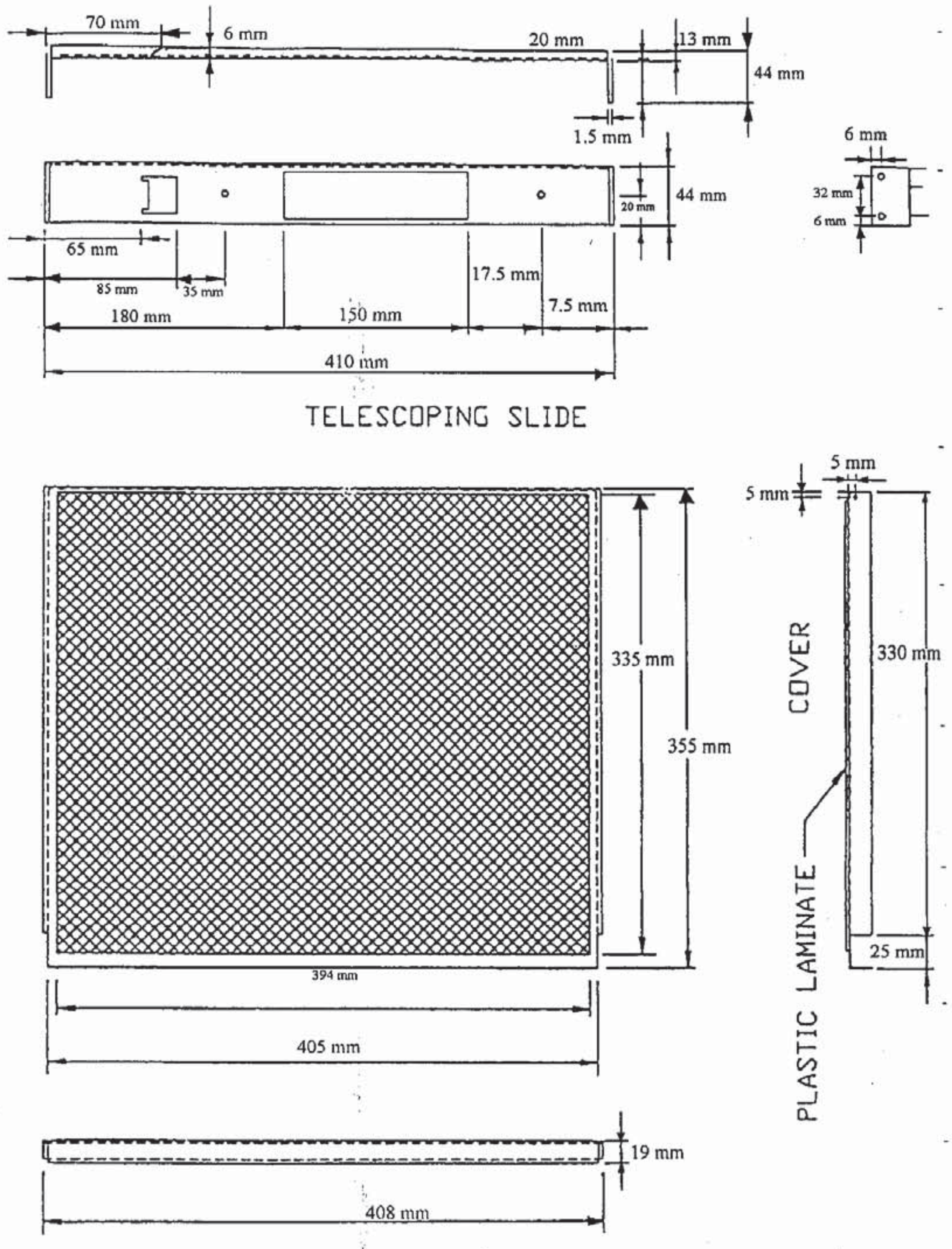
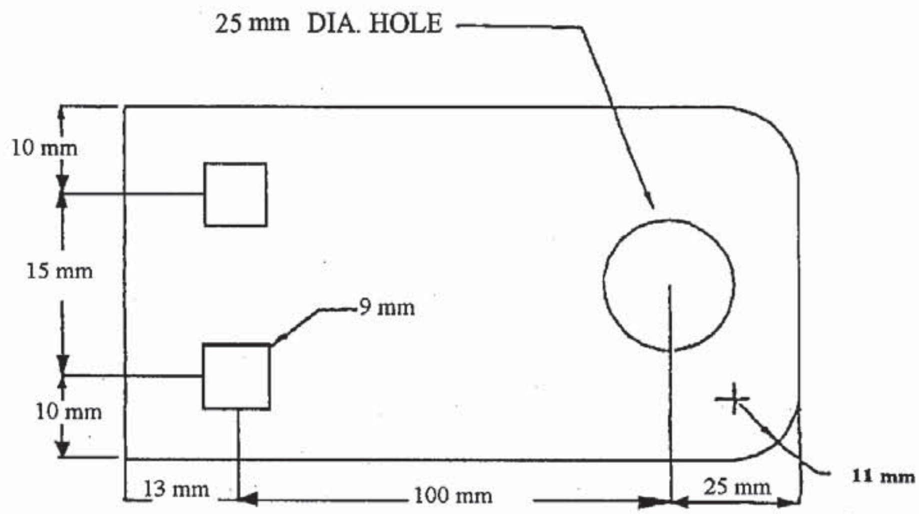


FIGURE 676-27

CABINET LIFTING BRACKET DETAILS



6061 -T6 EXTRUDED ALUMINUM RECTANGULAR BAR

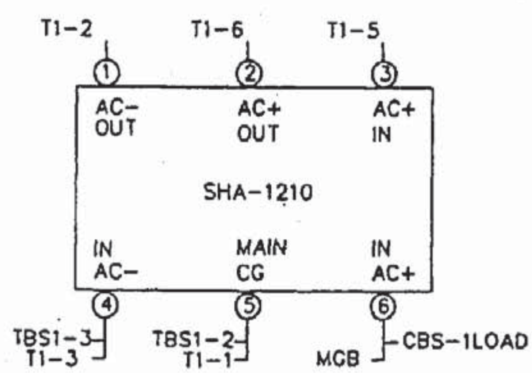
FIGURE 676-28

LOSS AND SPIKE TEST

FREQUENCY	INSERTION LOSS (dB)
60 Hz	0
10 Khz	34
50 Khz	55
100 Khz	76
500 Khz	76
2 Mhz	68
5 Mhz	58
10 Mhz	58
20 Mhz	63

FIGURE 676-29

TYPICAL CABINET TRANSIENT PR0TECTION DEVICE



THE 1210 SURRESTOR IS INSTALLED ON THE PDA #2 ASSEMBLY, AND ISOLATES THE INPUT FILE POWER SUPPLY AND CONTROLLER RECEPTACLE.

FIGURE 676-30

MAIN CABINET DOOR LIGHT SCHEMATIC

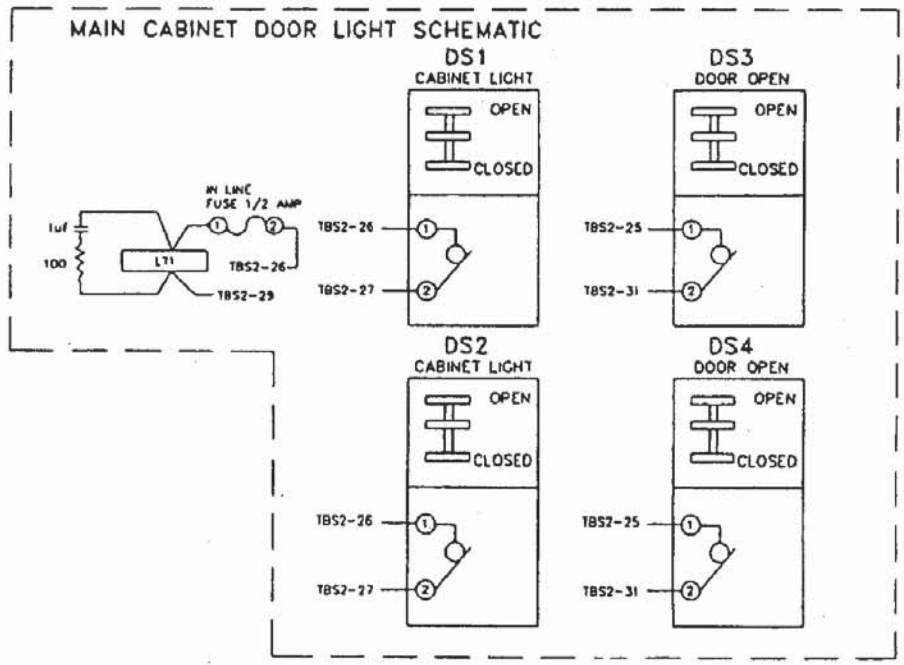
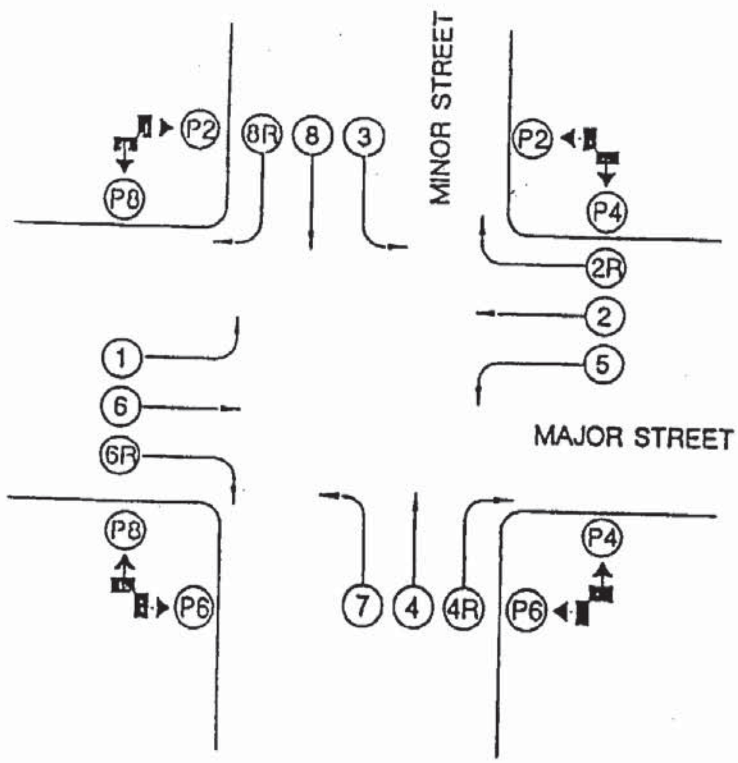


FIGURE 676-31
SIGNALIZATION MOVEMENT ASSIGNMENT



LEGEND

X - Vehicle movement number and signal head number.

PX - Pedestrian movement number and signal head number.

NOTE

XR - Used only when shown in S.O.P.

FIGURE 676-32

C1 DEFAULT PIN ASSIGNMENTS

PIN	SOURCE	DESTINATUON	FUNCTION /	COLOR
1	DC GROUND	TB7-12	LOGIC GROUND	
2	01-1	C4-1	SWPK 4P	RED
3	01-2	C4-2	SWPK 4P	GREEN
4	01-3	C4-3	SWPK 4	RED
5	01-4	C4-4	SWPK 4	YELLOW
6	01-5	C4-5	SWPK 4	GREEN
7	01-6	C4-6	SWPK 3	RED
8	01-7	C4-7	SWPK 3	YELLOW
9	01-8	C4-8	SWPK 3	GREEN
10	02-1	C4-9	SWPK 2P	RED
11	02-2	C4-10	SWPK 2P	GREEN
12	02-3	C4-11	SWPK 2	RED
13	02-4	C4-12	SWPK 2	YELLOW
14	DC GROUND	TB7-13	LOGIC GROUND	
15	02-5	C4-13	SWPK 2	GREEN
16	02-6	C4-14	SWPK 1	RED
17	02-7	C4-15	SWPK 1	YELLOW
18	02-8	C4-16	SWPK 1	GREEN
19	03-1	C4-17	SWPK 8P	RED
20	03-2	C4-18	SWPK 8P	GREEN
21	03-3	C4-19	SWPK 8	RED
22	03-4	C4-20	SWPK 8	YELLOW
23	03-5	C4-21	SWPK 8	GREEN
24	03-6	C4-22	SWPK 7	RED
25	03-7	C4-23	SWPK 7	YELLOW
26	03-8	C4-24	SWPK 7	GREEN
27	04-1	C4-25	SWPK 6P	RED
28	04-2	C4-26	SWPK 6P	GREEN
29	04-3	C4-27	SWPK 6	RED
30	04-4	C4-28	SWPK 6	YELLOW
31	04-5	C4-29	SWPK 6	GREEN
32	04-6	C4-30	SWPK 5	RED
33	04-7	C4-31	SWPK 5	YELLOW
34	04-8	C4-32	SWPK 5	GREEN
35	05-1	C4-33	SWPK 2P	Ø1 ARROW
36	05-2	C4-34	SWPK 6P	Ø5 ARROW
37	05-3	C4-35	SWPK 4P	Ø3 ARROW
38	05-4	C4-36	SWPK 8P	Ø7 ARROW
39	11-1	TB-5-1	DETECTOR 1	
40	11-2	TB-5-2	DETECTOR 2	
41	11-3	TB-5-3	DETECTOR 3	
42	11-4	TB-5-4	DETECTOR 4	
43	11-5	TB-5-5	DETECTOR 5	
44	11-6	TB-5-6	DETECTOR 6	
45	11-7	TB-5-7	DETECTOR 7	
46	11-8	TB-5-8	DETECTOR 8	
47	12-1	TB-5-9	DETECTOR 9	
48	12-2	TB-5-10	DETECTOR 10	
49	12-3	TB-5-11	HOLD (CONTROL ENABLE)	
50	12-4	TB-5-12	FORCE-OFF 2	
51	12-5	TB-5-13	RR 1 PREEMPT	
52	12-6	TB-5-14	RR 2 PREEMPT	

PIN	SOURCE	DESTINATUON	FUNCTION
53	12-7	TB-5-15	OFFSET 3
54	12-8	TB-5-16	OFFSET 2/TIME OF DAY SET
55	13-1	TB-5-17	SKIP
56	13-2	TB-5-18	DETECTOR 11
57	13-3	TB-5-19	DETECTOR 12
58	13-4	TB-5-20	DETECTOR 13
59	13-5	TB-6-1	DETECTOR 14
60	13-6	TB-6-2	DETECTOR 15
61	13-7	TB-6-3	DETECTOR 16
62	13-8	TB-6-4	SPAREINPUT
63	14-5	TB-6-5	SPAREINPUT
64	14-6	TB-6-6	SPAREINPUT
65	14-7	TB-6-7	DOOR OPEN
66	14-8	TB-6-8	PRETIME MODE
67	15-1	TB-6-9	MANUAL ENABLE INPUT
68	15-2	TB-6-10	SPARE INPUT
69	15-3	TB-6-11	FORCE-OFF 1 (ADVANCE)
70	15-4	TB-6-12	FLASH COMMAND IN
71	15-5	TB-6-13	PREEMPT # 1 INPUT (EVA)
72	15-6	TB-6-14	PREEMPT # 2 INPUT (EVB)
73	15-7	TB-6-15	PREEMPT # 3 (EVC)
74	15-8	TB-6-16	PREEMPT # 4 (EVD)
75	16-1	TB-6-17	PED 2
76	16-2	TS-6-18	PED 6
77	16-3	TS-6-19	PED 4
78	16-4	TB-6-20	PED 8
79	16-5	TB-7-1	INHIBIT MAX
80	16-6	TB-7-2	SPAREINPUT
81	16-7	TB-7-3	FLASH SENSE INPUT
82	16-8	TB-7-4	STOP TIME INPUT
83	06-1	TB-8-1	SPARE OUTPUT
84	06-2	TB-8-2	SPARE OUTPUT
85	06-3	TB-8-3	SPARE OUTPUT
86	06-4	TB-8-4	SPARE OUTPUT
87	06-5	TB-8-5	SPARE OUTPUT
88	06-6	TB-8-6	SPARE OUTPUT
89	06-7	TB-8-7	SPARE OUTPUT
90	06-8	TB-8-8	SPARE OUTPUT
91	07-1	TB-8-9	SPARE OUTPUT
92	DC GROUND	TB-7-14	LOGIC GROUND
93	07-2	TB-8-10	SPARE OUTPUT
94	07-3	TB-8-11	SPARE OUTPUT
95	07-4	TB-8-12	SPARE OUTPUT
96	07-5	TB-8-13	SPARE OUTPUT
97	07-6	TB-8-14	PREEMPT MONITOR DC OUTPUT
98	07-7	TB-8-15	SPARE OUTPUT
99	07-8	TB-8-16	SPARE OUTPUT
100	05-5	TB-8-17	SPARE OUTPUT
101	05-6	TB-8-18	FLASH OUTPUT
102	05-7	TB-8-19	RED MONITOR (KRM)
103	05-8	C4-37	WATCHDOG OUTPUT
104	DC GROUND	TB-7-15	LOGIC GROUND

FIGURE 676-32 (cont.)

C11S HARNESS WIRING LIST

PIN	SOURCE	DESTINATION	FUNCTION / COLOR
1	C1-2	SWPK 4P	RED
2	C1-3	SWPK 4P	GREEN
3	C1-4	SWPK 4	RED
4	C1-5	SWPK 4	YELLOW
5	C1-6	SWPK 4	GREEN
6	C1-7	SWPK 3	RED
7	C1-8	SWPK 3	YELLOW
8	C1-9	SWPK 3	GREEN
9	C1-10	SWPK 2P	RED
10	C1-11	SWPK 2P	GREEN
11	C1-12	SWPK 2	RED
12	C1-13	SWPK 2	YELLOW
13	C1-15	SWPK 2	GREEN
14	C1-16	SWPK 1	RED
15	C1-17	SWPK 1	YELLOW
16	C1-18	SWPK 1	GREEN
17	C1-19	SWPK 8P	RED
18	C1-20	SWPK 8P	GREEN
19	C1-21	SWPK 8	RED
20	C1-22	SWPK 8	YELLOW
21	C1-23	SWPK 8	GREEN
22	C1-24	SWPK 7	RED
23	C1-25	SWPK 7	YELLOW
24	C1-26	SWPK 7	GREEN
25	C1-27	SWPK 6P	RED
26	C1-28	SWPK 6P	GREEN
27	C1-29	SWPK 6	RED
28	C1-30	SWPK 6	YELLOW
29	C1-31	SWPK 6	GREEN
30	C1-32	SWPK 5	RED
31	C1-33	SWPK 5	YELLOW
32	C1-34	SWPK 5	GREEN
33	C1-35	SWPK 2P	SP FUNCTION
34	C1-36	SWPK 6P	SP FUNCTION
35	C1-37	SWPK 4	SP FUNCMON
36	C1-38	SWPK SP	SCH FLASHER
37	C1-103	WDT-MU	WATCHDOG

FIGURE 676-32 (cont.)

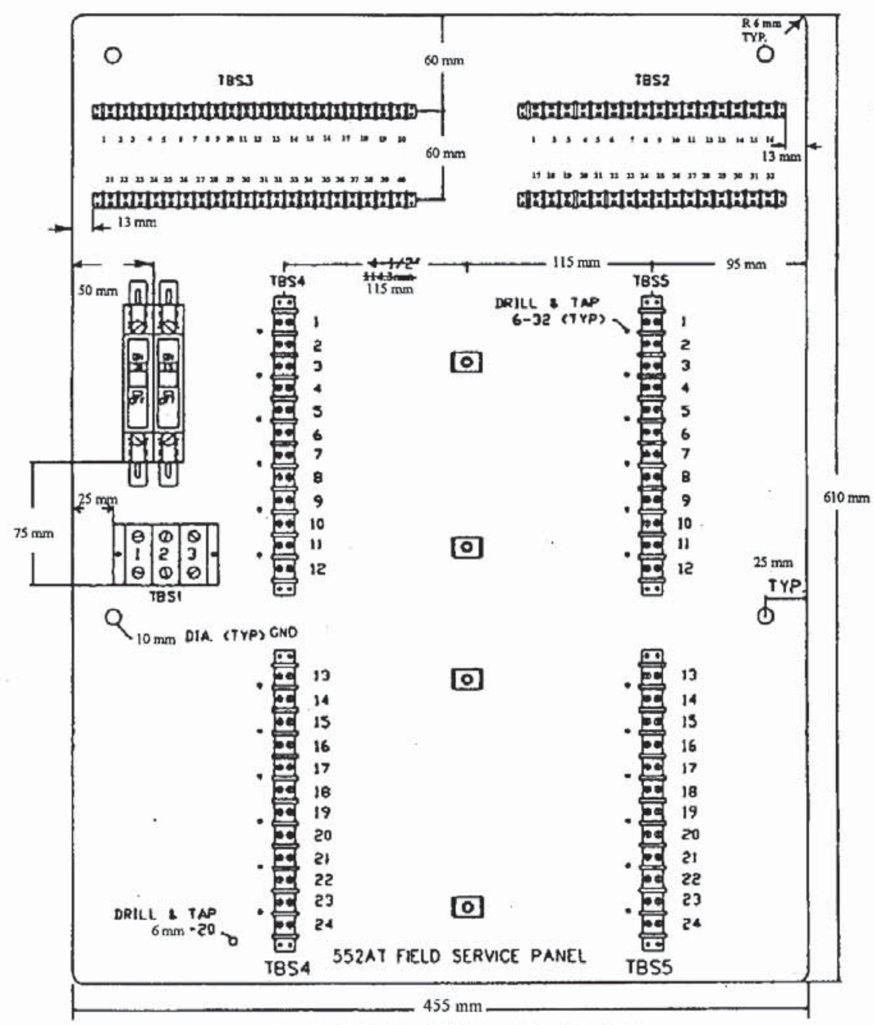
T-1 (ACIA1/MODEM 1)	
PIN	FUNCTIONS
1	AUDIO IN
2	AUDIO IN
3	DCD
4	RTS
5	TXD
6	CTS
7	RXD
8	AUDIO OUT
9	AUDIO OUT
10	DC GND

C2S	
PIN	FUNCTION
A	MODEM 1 AUDIO IN
B	MODEM 1 AUDIO IN
C	MODEM 1 AUDIO OUT
D	+5 VDC
E	MODEM 1 AUDIO OUT
F	-5 VDC
H	ACIA 1 DCD
J	ACIA 1 RTS
K	ACIA 1 TXD
L	ACIA 1 RXD
M	ACIA 1 CTS
N	DC GND
P	+12 VDC *
R	-12 VDC *

* JUMPER STRAP OPTION

FIGURE 676-33

FIELD SERVICE PANEL



552AT FIELD SERVICE PANEL

FIGURE 676-34

SERVICE PANELS LOCATION LAYOUT

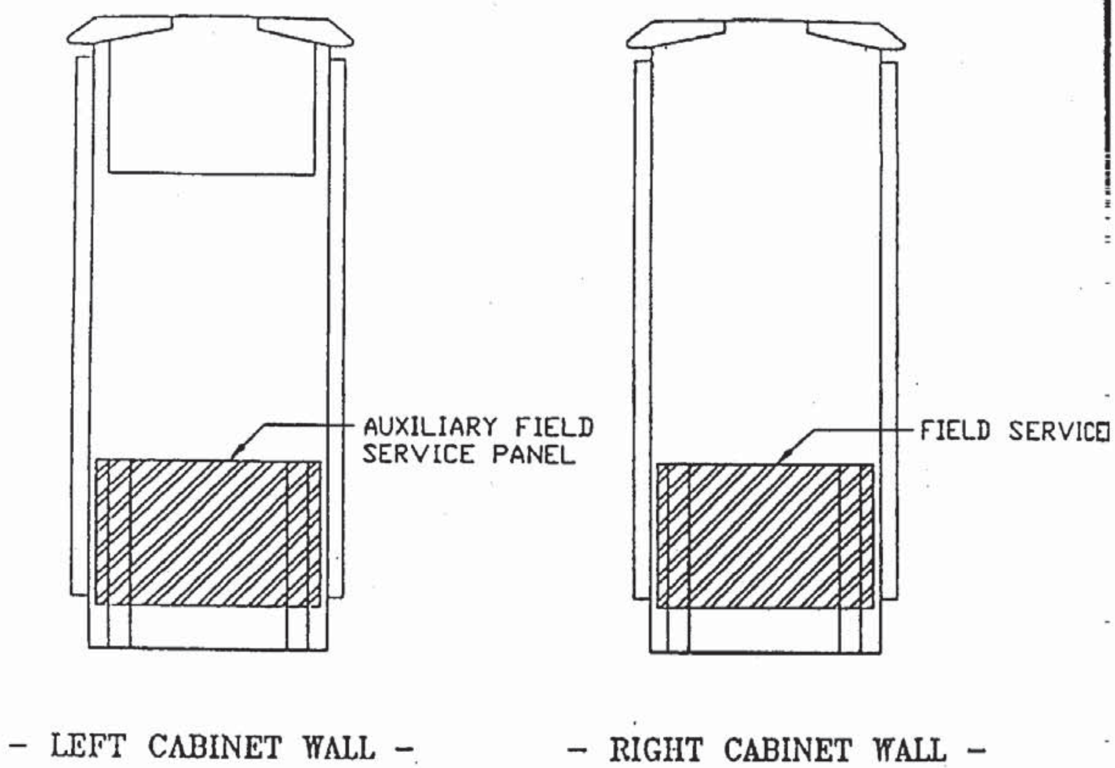


FIGURE 676-35

WIRING FOR 552 AT FIELD SERVICE PANEL

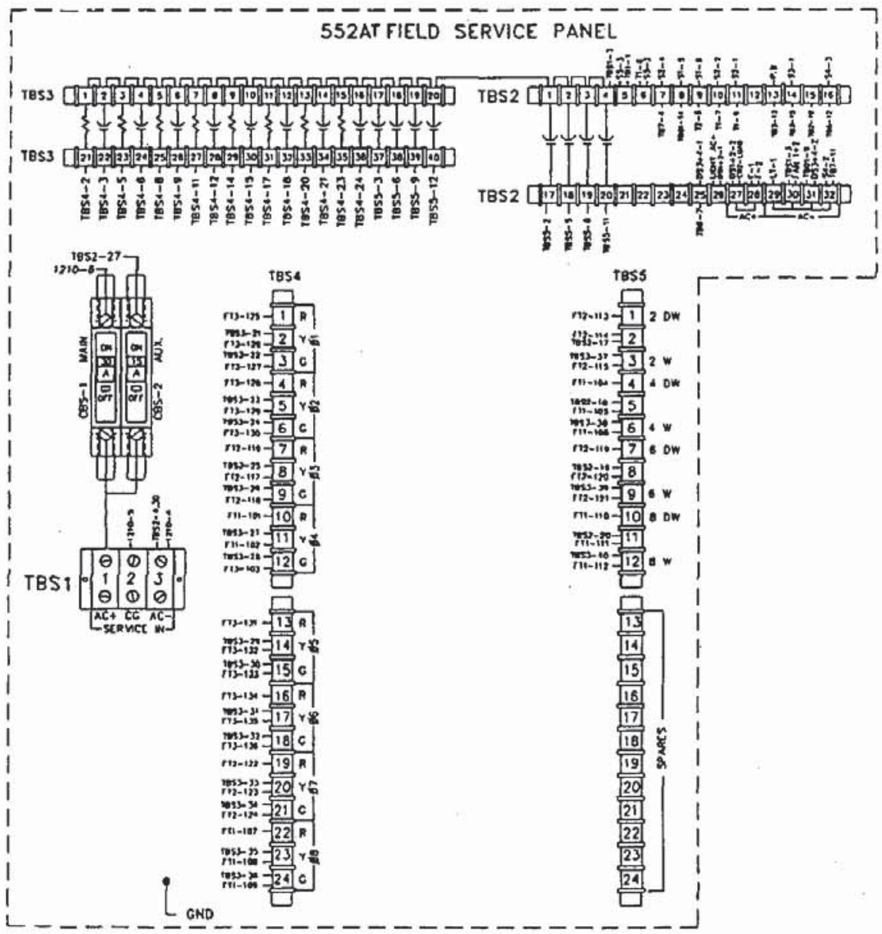


FIGURE 676-36
FIELD PANEL WIRE SIZES

	CONNECTION		WIRE SIZE #	
(a)	TBS1-1	to CBS1 & CBS2	8 AWG	
(b)	CSB2	to TBS2-1	14 AWG	
(c)	TBS1-2	to TBS2-3	14 AWG	
(d)	TBS1-2	to AC-BUSS	8 AWG	
(e)	TBS1-3	to EQP GND BUSS	8 AWG	
(f)	TBS4	to FT Terminals (12 wires)	14 AWG	(1)
(g)	TBS5	to FT Terminals (12 wires)	14 AWG	(1)
(h)	TBS6	to FT Terminals (12 wires)	14 AWG	(1)
(i)	CBS1	to CB1-1	8 AWG	(2)
(j)	TBS1-2	to T1-2	8 AWG	(2)
(k)	TBS1-3	to T1-1	8 AWG	(3)
(l)	All Wiring from TBS2 to Rack Assembly		18 AWG	(3)
(m)	TBS2-4	to TB01-9	14 AWG	(1)
(n)	TBS2-5	to TB01-10	14 AWG	(1)
(o)	SHP-1210-6	to MCB-(Line)	8 AWG	(2)
(p)	MCB-(Load)	to MC-(In)	8 AWG	(2)
(q)	MC-(Out)	to SCB1-(AC+ Light Box)	8 AWG	(2)

Note: A special flexible conduit is required. The wires shall be routed thru the conduit. Flexible conduit shall be Chem Lab Products, Inc. floating vacuum hose Part #P770 (38mm D) or approved equivalent.

FIGURE 676-37

AUXILIARY FIELD SERVICE PANEL

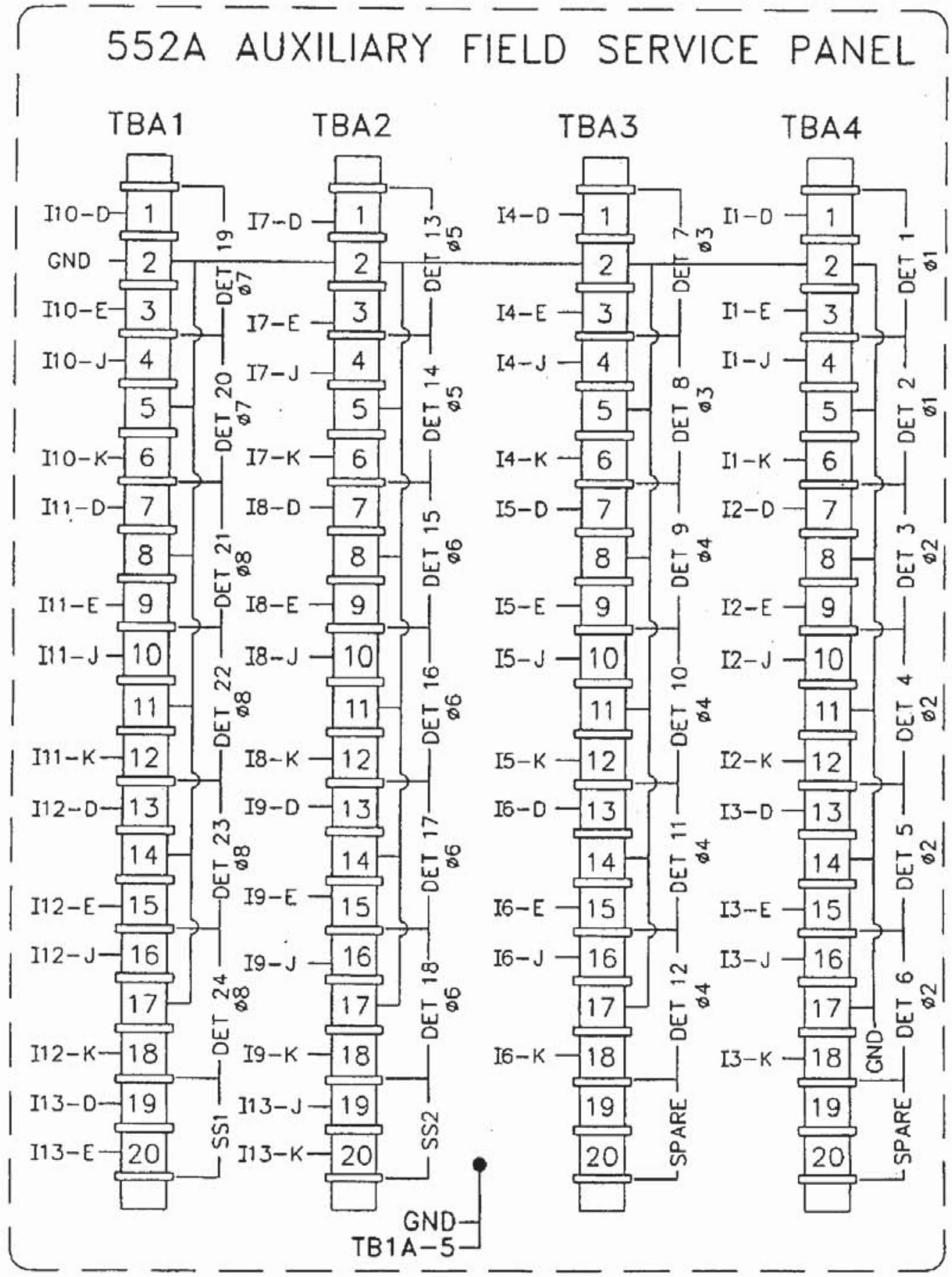
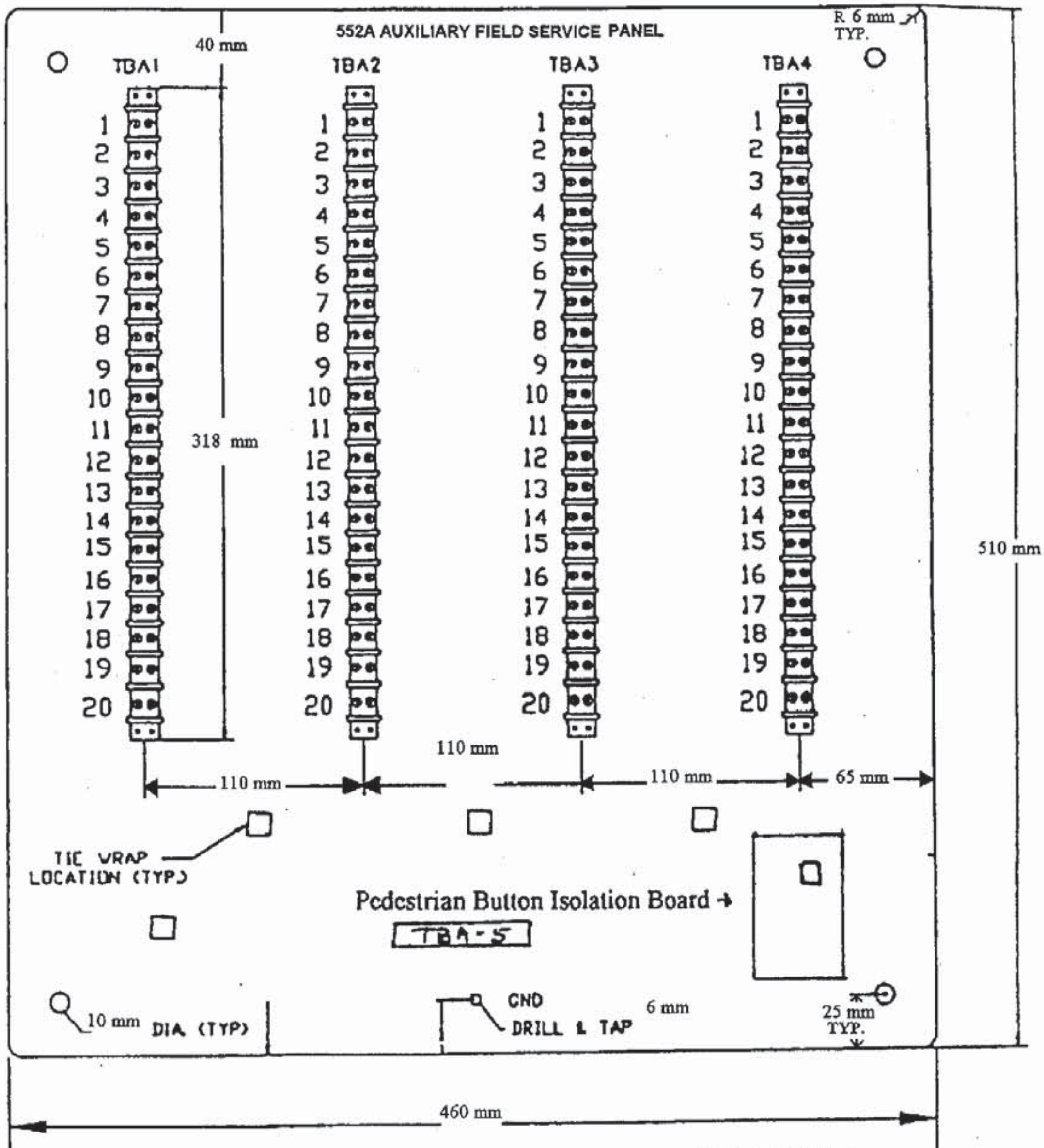


FIGURE 676-38

AUXILIARY FIELD SERVICE PANEL LAYOUT



552A AUXILIARY FIELD SERVICE PANEL

FIGURE 676-39

PEDESTRIAN PUSH BUTTON ISOLATION BOARD

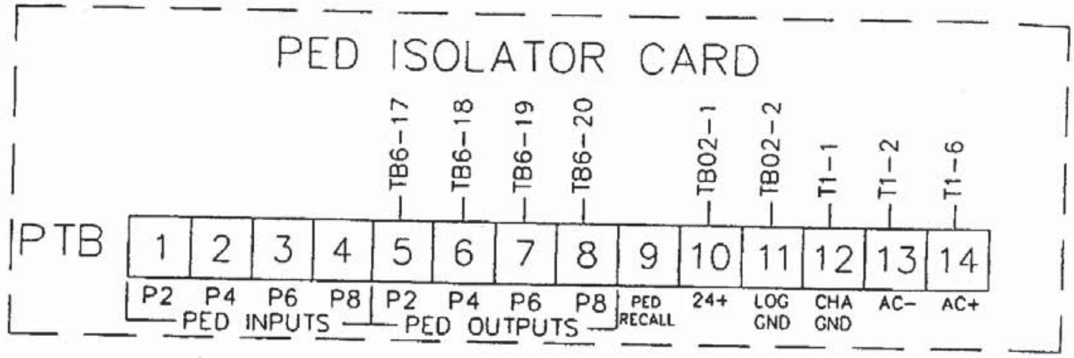


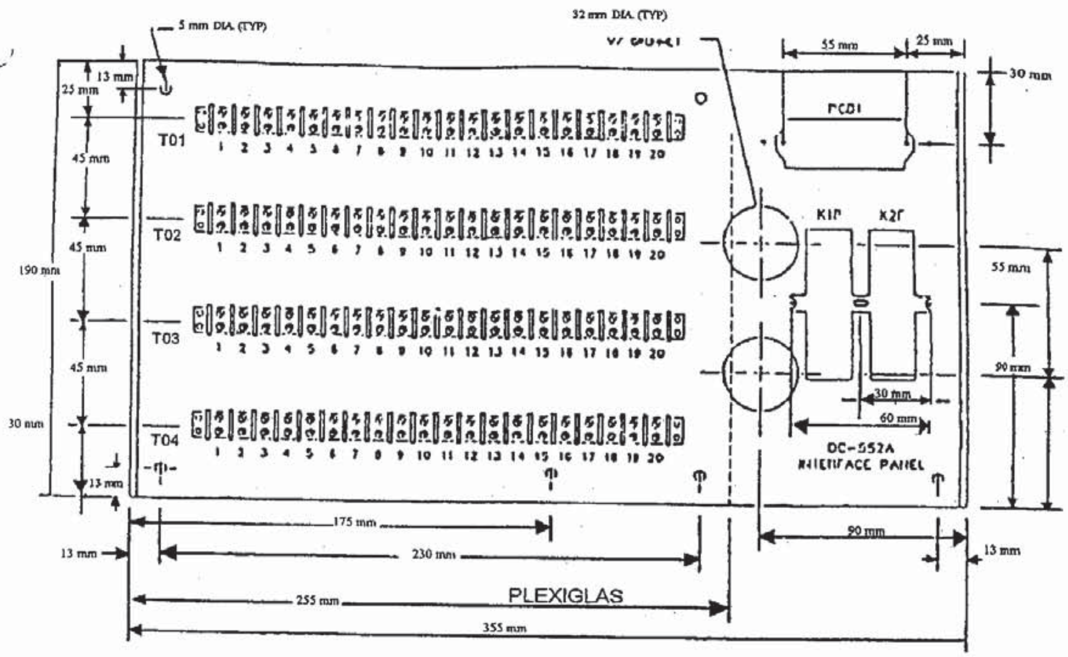
FIGURE 676-40
AUXILIARY FIELD SERVICE PANEL WIRING

TERMINAL	FUNCTION
TBA1-1 TO I 10-D	DET 19 – Ø VEH DET
TBA1-2 TO GND	GND
TBA1-3 TO I 10-E	DET 19 – Ø7 VEH DET
TBA1-4 TO I 10-J	DET 20 – Ø7 VEH DET
TBA1-5 TO GND	GND
TBA1-6 TO I 10-K	DET 20 – Ø7 VEH DET
TBA1-7 TO I-11-D	DET 21 – Ø8 VEH DET
TBA1-8 TO GND	GND
TBA1-9 TO I 11-E	DET 21 – Ø8 VEH DET
TBA1-10 TO I 11-J	DET 22 – Ø8 VEH DET
TBA1-11 TO GND	GND
TBA1-12 TO I 11-K	DET 22 – Ø8 VEH DET
TBA1-13 TO I 12-D	DET 23 – Ø8 VEG DET
TBA1-14 TO GND	GND
TBA 1-15 TO I 12-E	DET 23 – Ø8 VEH DET
TBA1-16 TO I 12-J	DET 24 – Ø8 VEH DET
TBA1-17 TO GND	GND
TBA1-18 TO I 12-K	DET 24 – Ø8 VEH DET
TBA1-19 TO I-13-D	SS1 DET
TBA1-20 TO I 13 E	SS1 DET
TBA2-1 TO I 7-D	DET 13 – Ø5 VEH DET
TBA2-2 TO GND	GND
TBA2-3 TO I 7-E	DET 13 – Ø5 VEH DET
TBA1-19 TO I-13-D	SS1 DET
TBA1-20 TO I 13 E	SS1 DET
TBA2-1 TO I 7-D	DET 13 – Ø5 VEH DET
TBA2-2 TO GND	GND
TBA2-3 TO I 7-E	DET 13 – Ø5 VEH DET
TBA2-4 TO I 7-J	DET 14 – Ø5 VEH DET
TBA2-5 TO GND	GND
TBA2-6 TO I 7-K	DET 14 – Ø5 VEH DET
TBA2-7 TO I-8-D	DET 15 – Ø6 VEH DET
TBA2-8 TO GND	GND
TBA2-9 TO I 8-E	DET 15 – Ø6 VEH DET
TBA2-10 TO I 8-J	DET16 – Ø6 VEH DET
TBA2-11 TO GND	GND
TBA2-12 TO I 8-K	DET 16 – Ø6 VEH DET
TBA2-13 TO I 9-D	DET 17 – Ø6 VEH DET
TBA2-14 TO GND	GND
TBA2-15 TO I 9-E	DET 17 – Ø6 VEH DET
TBA2-16 TO I 9-J	DET 18 – Ø6 VEH DET
TBA2-17 TO GND	GND
TBA2-18 TO I 9-K	DET 18 – Ø6 VEH DET
TBA2-19 TO I-13-J	SS2 DET
TBA2-29 TO I 13 K	SS2 DET

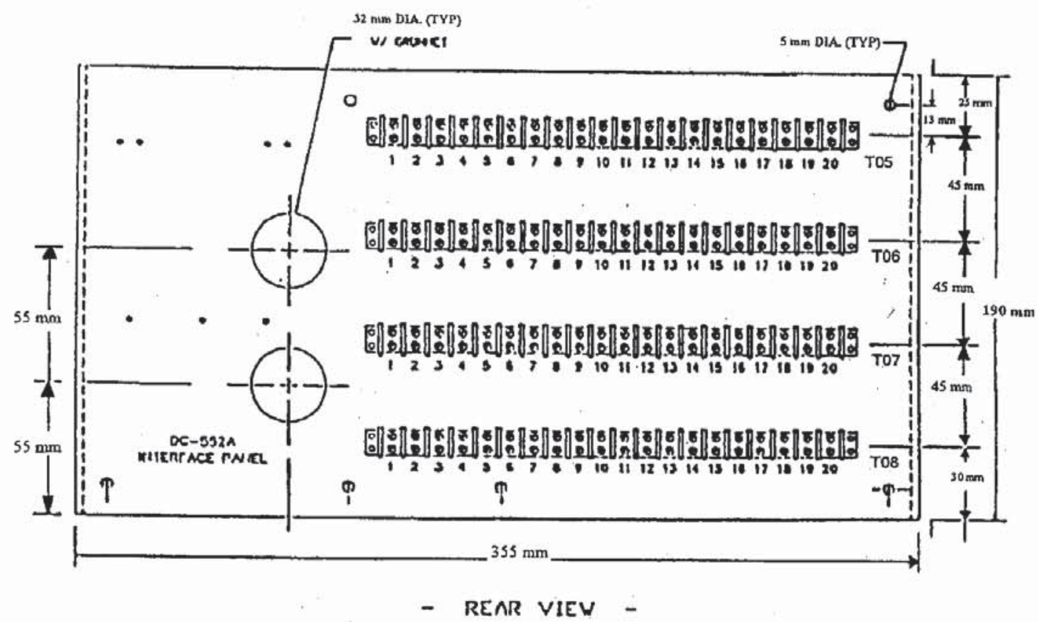
FIGURE 676-40
AUXILIARY FIELD SERVICE PANEL WIRING
(Continued)

TERMINAL	FUNCTION
TBA3-1 TO I 4-D	DET 7 – Ø3 VEH DET
TBA3-2 TO GND	GND
TBA3-3 TO I 4-E	DET 7 – Ø3 VEH DET
TBA3-4 TO I 4-J	DET 8 – Ø3 VEH DET
TBA3-5 TO GND	GND
TBA3-6 TO I 4-K	DET 8 – Ø3 VEH DET
TBA3-7 TO I-5-D	DET 9 – Ø4 VEH DET
TBA3-8 TO GND	GND
TBA3-9 TO I 5-E	DET 9 – Ø4 VEH DET
TBA3-10 TO I 5-J	DET 10 – Ø4 VEH DET
TBA3-11 TO GND	GND
TBA3-12 TO I 5-K	DET 10 – Ø4 VEH DET
TBA3-13 TO I 6-D	DET 11 – Ø4 VEH DET
TBA3-14 TO GND	GND
TBA3-15 TO I 6-E	DET11 – 04 VEH DET
TBA3-16 TO I 6-J	DET12 – Ø4 VEH DET
TBA3-17 TO GND	GND
TBA3-18 TO I 6-K	DET 12 – Ø4 VEH DET
TBA3-19 TO N/U	SPARE
TBA3-20 TO N/U	SPARE
TBA4-1 TO I 1-D	DET 1 – Ø5 VEH DET
TBA4-2 TO GND	GND
TBA4-3 TO I 1-E	DET 1 – Ø5 VEH DET
TBA4-4 TO I 1-J	DET 2 – Ø5 VEH DET
TBA4-5 TO GND	GND
TBA4-6 TO I 1-K	DET 2 – Ø5 VEH DET
TBA4-7 TO I-2-D	DET 3 – Ø6 VEH DET
TBA4-8 TO GND	GND
TBA4-9 T I 2-E	DET 3 – Ø6 VEH DET
TBA4-10 TO I 2-J	DET 4 – Ø6 VEH DET
TBA4-11 TO GND	GND
TBA4-12 TO I 2-K	DET 4 – Ø6 VEH DET
TBA4-13 TO I 3-D	DET 5 – Ø6 VEH DET
TBA4-14 TO GND	GND
TBA4-15 TO I 3-E	DET 5 – Ø6 VEH DET
TBA4-16 TO I 3-J	DET 6 – Ø6 VEH DET
TBA4-17 TO GND	GND
TBA4-18 TO I 3-K	DET 6 – Ø6 VEH DET
TBA4-19 TO N/U	SPARE
TBA4-20 TO N/U	SPARE

FIGURE 676-41
INTERFACE PANEL LAYOUT



- FRONT VIEW -



- REAR VIEW -

FIGURE 676-42

INTERFACE PANEL DETAILS

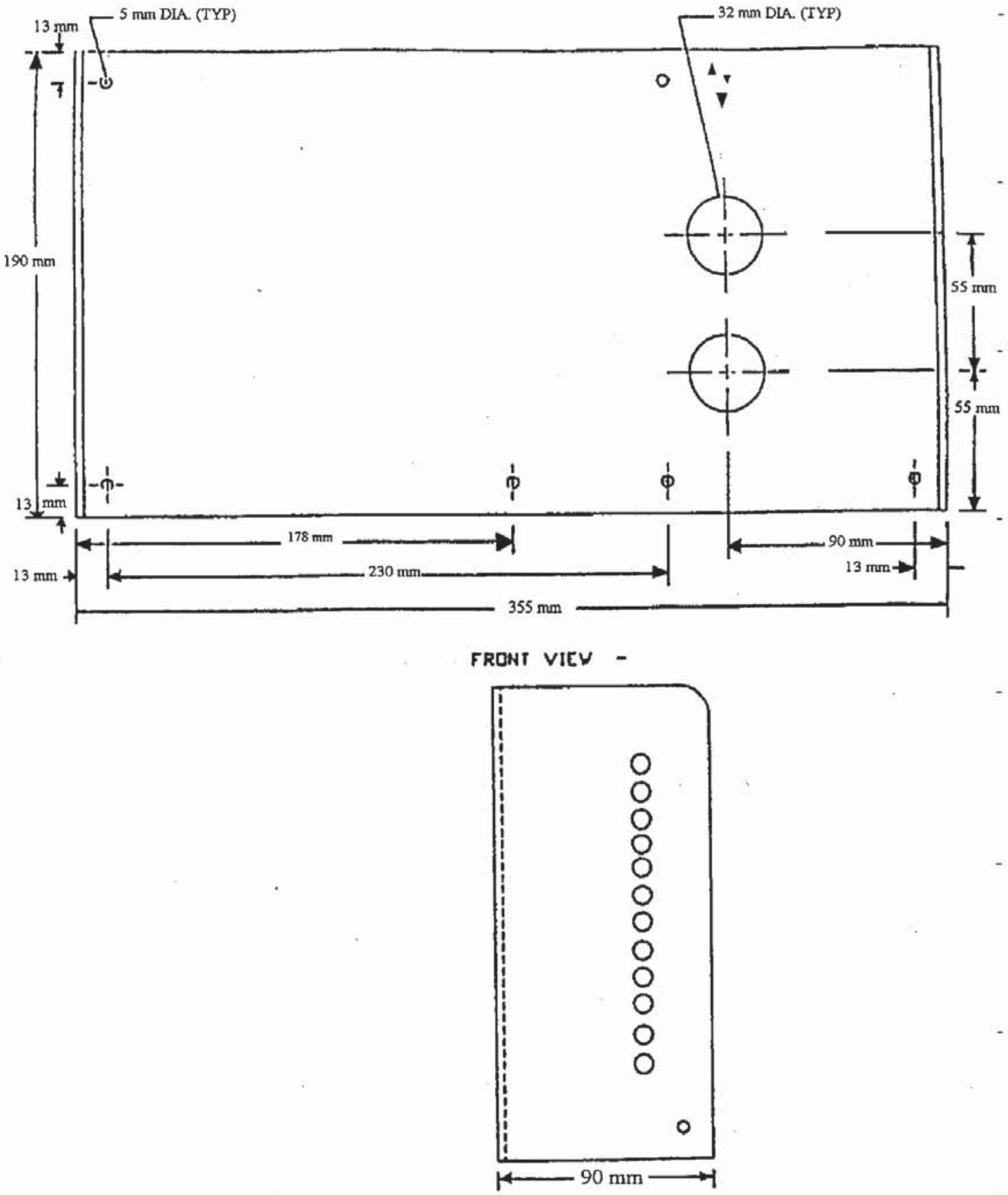


FIGURE 676-43

INTERFACE PANEL PLEXIGLASS DETAIL

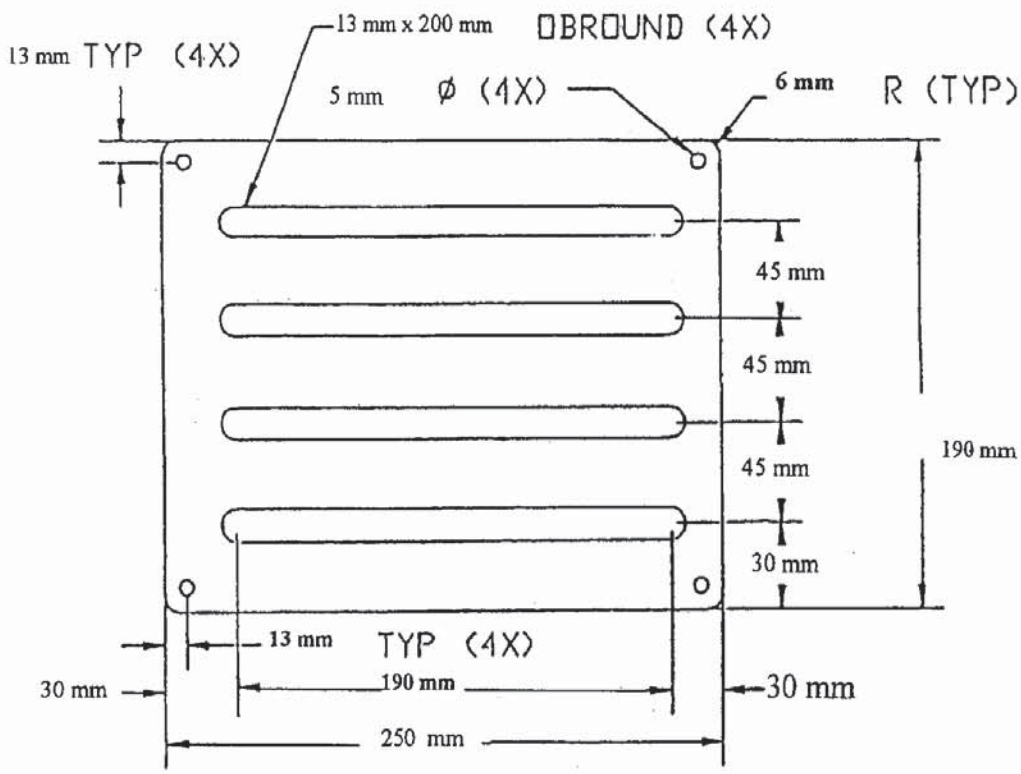


FIGURE 676-44
TABLE OF WIRING ASSIGNMENTS BETWEEN INTERFACE PANEL AND VARIOUS TERMINAL PANELS

INTERFACE PANEL	DESTINATION	FUNCTION
TB1-1	T1-5	AC+
TB1-3	T1-3	AC- GROUND
TB1-5	T1-1	GROUND
TB1-19	TB5-16	OFFSET 2
TB1-20	TB5-15	OFFSET 3
TB2-7	TB5-2	Ø CALL 1
TB2-8	TB5-6	Ø CALL 3
TB2-9	TB5-8	Ø CALL 4
TB2-10	TB5-10	Ø CALL 5
TB2-11	TB6-1	Ø CALL 7
TB2-12	TB6-3	Ø CALL 8
TB2-13	TB5-17	SKIP
TB2-14	TB5-11	HOLD/CONTROL ENABLE
TB2-15	TB6-11	FORCE OFF 1/ADV.
TB2-16	TB5-12	FORCE OFF 2
TB2-18	TB8-14	PREEMPT MONITOR
TB2-19	TBS2-15	CONTROLLER STATUS
TB3-9	TB01-14	FLASH MONITOR
TB3-10	T2-6	FLASH COMMAND
TB3-13	TBS2-13	POLICE MANUAL
TB3-14	TB2-15	MANUAL ADVANCE
TB3-15	TBS2-14	AUTO/MANUAL
TB3-16	TB6-9	CONTROL ENABLE
TB3-20	T3-1	PDA #2 +24VDC
TB4-1	FT3-127	1 GREEN
TB4-2	FT3-130	2 GREEN
TB4-3	FT2-118	3 GREEN
TB4-4	FT1-103	4 GREEN
TB4-5	FT3-133	5 GREEN
TB4-6	FT3-136	6 GREEN
TB4-7	FT2-124	7 GREEN
TB4-8	FT1-109	8 GREEN
TB4-9	FT2-115	2P GREEN
TB4-10	FT1-106	4P GREEN
TB4-11	FT2-121	6P GREEN
TB4-12	FT1-112	8P GREEN
TB6-12	TBS2-16	UNIFORM CODE FLASH (DC)
TB7-3	TB02-4	FLASH SENSE
TB7-4	TB02-3, TBS2-7	STOP TIME
TB7-10	T3-3	DC GND
TB7-11	TBS2-32	DC GND
TB8-19	TB02-6	RED MONITOR
PCB1-3	TBA5-1	RECEIVE #1
PCB1-5	TBA5-2	TWISTED PAIR
PCB1-7	TBA5-3	TRANSMIT #1
PCB1-9	TBA5-4	TWISTED PAIR
PCB-1	TO CHASSIS GND CAHSSIS GROUND	

FIGURE 678-1

MODEL D210 CONFLICT-VOLTAGE MONITOR WIRING CHART

CHANNEL	FUNCTION	SWPK#	OUTPUT FILE TERM. #
1	RED	1	FT3-125
	YELLOW	1	FT3-126
	GREEN	1	FT3-127
2	RED	2	FT3-128
	YELLOW	2	FT3-129
	GREEN	2	FTE-130
3	RED	3	FT2-116
	YELLOW	3	FT1-117
	GREEN	3	FT2-118
4	RED	4	FT1-101
	YELLOW	4	FT1-101
	GREEN	4	FT1-103
5	RED	5	FT3-131
	YELLOW	5	FT3-132
	GREEN	5	FT3-133
6	RED	6	FT3-134
	YELLOW	6	FT3-135
	GREEN	6	FT3-136
7	RED	7	FT2-122
	YELLOW	7	FT2-123
	GREEN	7	FT2-124
8	RED	8	FT1-107
	YELLOW	8	FT1-108
	GREEN	8	FT1-109
9	RED	T&B	
	YELLOW	T&B	
	GREEN	T&B	
10	RED	T&B	
	YELLOW	T&B	
	GREEN	T&B	
11	RED	T&B	

FIGURE 678-1

MODEL 210 CONFLICT-VOLTAGE MONITOR WIRING CHART
(continued)

CHANNEL	FUNCTION	SWPK#	OUTPUT FILE TERM. #
	YELLOW	T&B	
	GREEN	T&B	
12	RED	T&B	
	YELLOW	T&B	
	GREEN	T&B	
13	RED (DON’T WALK)	2P	SEE NOTE #2
	YELLOW	2P	T&B
	GREEN (WALK)	2P	FT2-115
14	RED (DON’T WALK)	4P	SEE NOTE #2
	YELLOW	4P	T&B
	GREEN	4P	FT1-106
15	RED (DON’T WALK)	6P	SEE NOTE #2
	YELLOW	6P	T&B
	GREEN (WALK)	6P	FT2-121
16	RED (DON’T WALK)	8P	SEE NOTE #2
	YELLOW	8P	T&B
	GREEN (WALK)	8P	FT1-112

NOTE:
(1) T&B – Conductors connected to pin, 610 mm in length with ring lug or unconnected end, tied and bundled separately, mark with Pin # and Function.
(2) For Red Monitor Hookup – See Figure 678-4 “Red Monitor Program Board”.

FIGURE 678-2

MODEL 210 CONFLICT-VOLTAGE MONITOR CONNECTOR PIN LIST

PIN	FUNCTION	OUTPUT FILE TERMINAL #
1	CHANNEL 2 GREEN	FT3-130
2	CHANNEL 13 GREEN	FT2-115
3	CHANNEL 6 YELLOW	FT2-135
4	CHANNEL 4 GREEN	FT1-103
5	CHANNEL 14 GREEN	FT1-108
6	CHANNEL 9 YELLOW	T&B
7	CHANNEL 5 GREEN	FT3-133
8	CHANNEL 13 YELLOW	T&B
9	CHANNEL 1 YELLOW	FTE-126
10	CHANNEL 7 GREEN	FT2-124
11	CHANNEL 14 YELLOW	FT2-117
12	CHANNEL 3 YELLOW	FT2-117
13	CHANNEL 9 GREEN	T&B
14	NOT ASSIGNED	-----
15	CHANNEL 11 YELLOW	T&B
16	CHANNEL 9 YELLOW	T&B
17	NOT ASSIGNED	-----
--	KEY SLOT	-----
18	CHANNEL 12 YELLOW	T&B
19	NOT ASSIGNED	-----
20	CHASSIS GROUND	O1-9
21	AC NEUTRAL	O1-10
*22	WATCHDOG TIMER INPUT	C4-37
23	24 VDC INPUT	O2-1
24	CONNECTED TO 25	-----
25	CONNECTED TO 24	-----
26	NOT ASSIGNED	-----
27	NOT ASSIGNED	-----
28	OUTPUT SW SIDE 1	AC+

*Indicates active level is a low voltage.

FIGURE 678-2

MODEL 210 CONFLICT-VOLTAGE MONITOR CONNECTOR PIN LIST
(continued)

PIN	FUNCTION	OUTPUT FILE TERMINAL #
A	CHANNEL 2 YELLOW	FT3-129
B	CHANNEL 6 GREEN	FT3-136
C	CHANNEL 15 GREEN	FT2-121
D	CHANNEL 4 YELLOW	FT1-102
E	CHANNEL 8 GREEN	FT1-109
F	CHANNEL 16 GREEN	FT1-112
G	CHANNEL 5 YELLOW	FT3-132
H	CHANNEL 1 GREEN	FT3-127
K	CHANNEL 15 YELLOW	T&B
L	CHANNEL 7 YELLOW	FT2-123
M	CHANNEL 3 GREEN	FT2-118
N	CHANNEL 3 GREEN	T&B
P	NOT ASSIGNED	-----
R	CHANNEL 10 GREEN	T&B
S	CHANNEL 11 GREEN	T&B
T	NOT ASSIGNED	------
U	CHANNEL 10 YELLOW	T&B
--	KEY SLOT	-----
V	CHANNEL 12 GREEN	T&B
W	NOT ASSIGNED	-----
X	NOT ASSIGNED	-----
Y	DC GROUND INPUT	O2-2
Z *	EXTERNAL RESET INPUT	O2-5
AA	24 VDC INPUT	O2-1
BB *	STOP TIMING OUT	O2-3
CC	NOT ASSIGNED	-----
DD	NOT ASSIGNED	-----
EE	OUTPUT SW SIDE 2	O1-12
FF	AC+ INPUT	O1-11

*Indicated active level is a low voltage

FIGURE 678-3
MODEL 210 CONFLICT-VOLTAGE MONITOR RED INPUT CONNECTOR PIN ASSIGNMENTS

PIN	FUNCTION	RED MONITOR PROGRAM BOARD INPUT (RMC)
1	CHANNEL 15 RED	1
2	CHANNEL 16 RED	2
3	CHANNEL 14 RED	3
4 SPARE		4
5	CHANNEL 13 RED	5
6 SPARE		6
7	CHANNEL 12 RED	7
8 RRPE	INPUT	8
9	CHANNEL 10 RED	9
10	CHANNEL 11 RED	10
11	CHANNEL 9 RED	11
12	CHANNEL 8 RED	12
13	CHANNEL 7 RED	13
14	CHANNEL 6 RED	14
15	CHANNEL 5 RED	15
16	CHANNEL 4 RED	16
17	CHANNEL 3 RED	17
18	CHANNEL 2 RED	18
19	CHANNEL 1 RED	19
20	“RED ENABLE” INPUT	20

FIGURE 678-4

MODEL 210 RED MONITOR PROGRAM BOARD

P1 FIELD	TERM	FUNCTION 210	RMC D210	CHAN.
1	125	1R	(19)	1
2	126	2R	(18)	2
3	116	3R	(17)	3
4	101	4R	(16)	4
5	131	5R	(15)	5
6	134	6R	(14)	6
7	122	7R	(13)	7
8	107	8R	(12)	8
9	T&B	OL1R	(11)	9
10	T&B	OL2R	(9)	10
11	T&B	OL3R	(10)	11
12	T&B	OL4R	(7)	12
13	AC+	AC+ TO DISABLE	----	---
14	AC+	RED MONITORING	---	---

P2 FIELD	TERM	FUNCTION 210	RMC D210	CHAN.
1	T&B	O13R	(5)	13
2	T&B	O14R	(3)	14
3	T&B	O15R	(1)	15
4	T&B	O16R	(2)	16
5	T&B	RE RELAY COM	---	---
6	T&B	RM RELAY N.C.	---	---

FIGURE 678-4

MODEL 210 RED MONITOR PROGRAM BOARD
(Continued)

P3	FUNCTION	DESTINATION
1	"RM" RELAY COIL (+24VDC)	02-1 (OUTPUT FILE #1)
2	"RM" RELAY COIL	TB8-19 (INTERFACE PANEL

P4	FUNCTION	DESTINATION
1	SPARE INPUT (RR-PE)	T&B
2	SPARE INPUT	T&B
3	SPARE INPUT	T&B

NOTE:

(1) T&B – Conductors connected to pin, 610 mm in length with ring lug on unconnected end, tied and bundled separately, mark with pin # and function

(2) The "Red Monitor Program Board" shall use Shunt Jumpers to enable and disable each Monitor Channel Red input. The Program Board shall be designed so that installing a jumper in position "a" will program the Red Monitor Channel to the load switch output and installing a jumper in position "b" will disable the Red Monitor Channel. Small terminal blocks with wire jumpers shall not be used.

FIGURE 678-5
MODEL 210 RED MONITOR PROGRAM BOARD SCHEMATIC

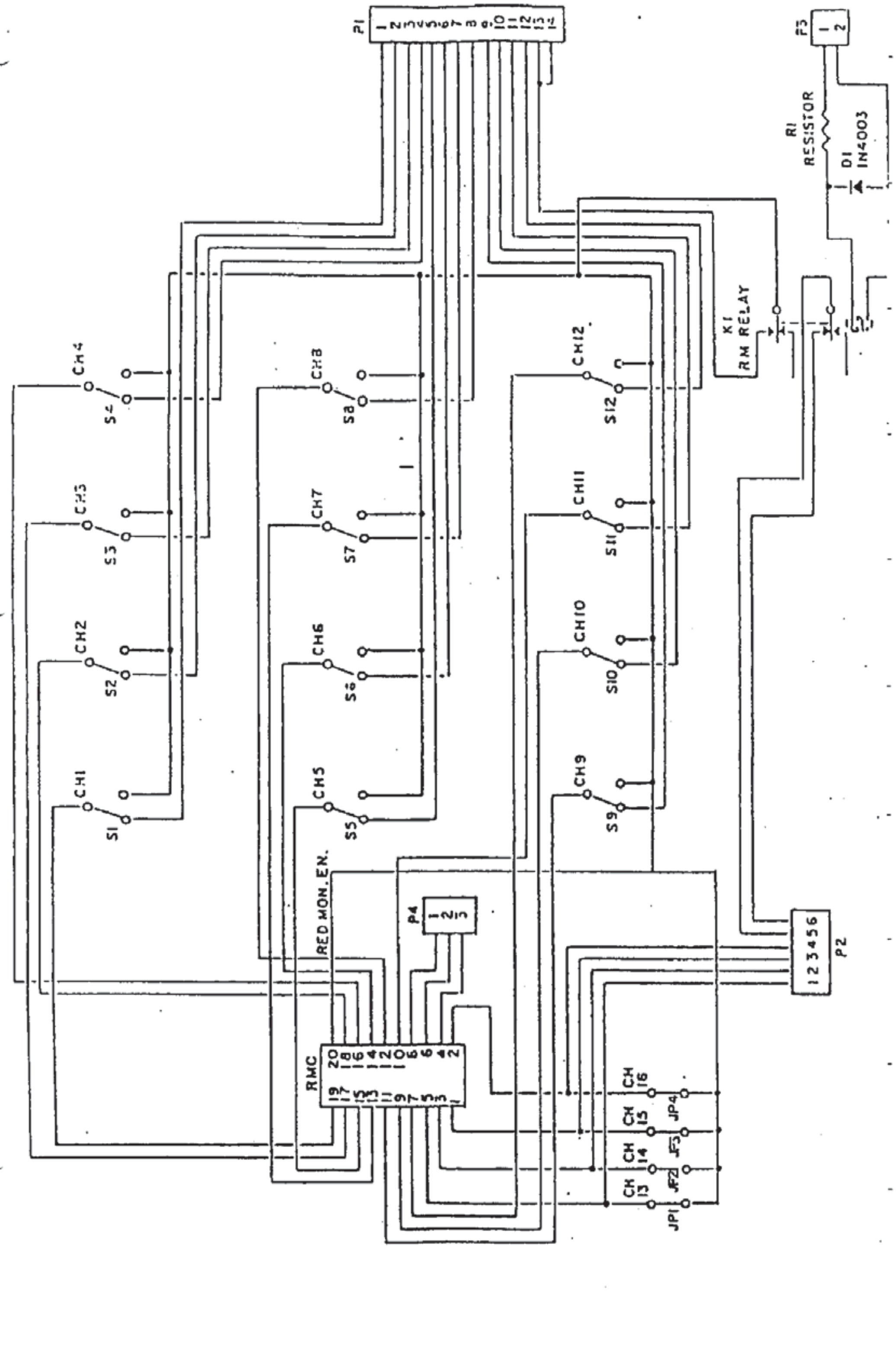
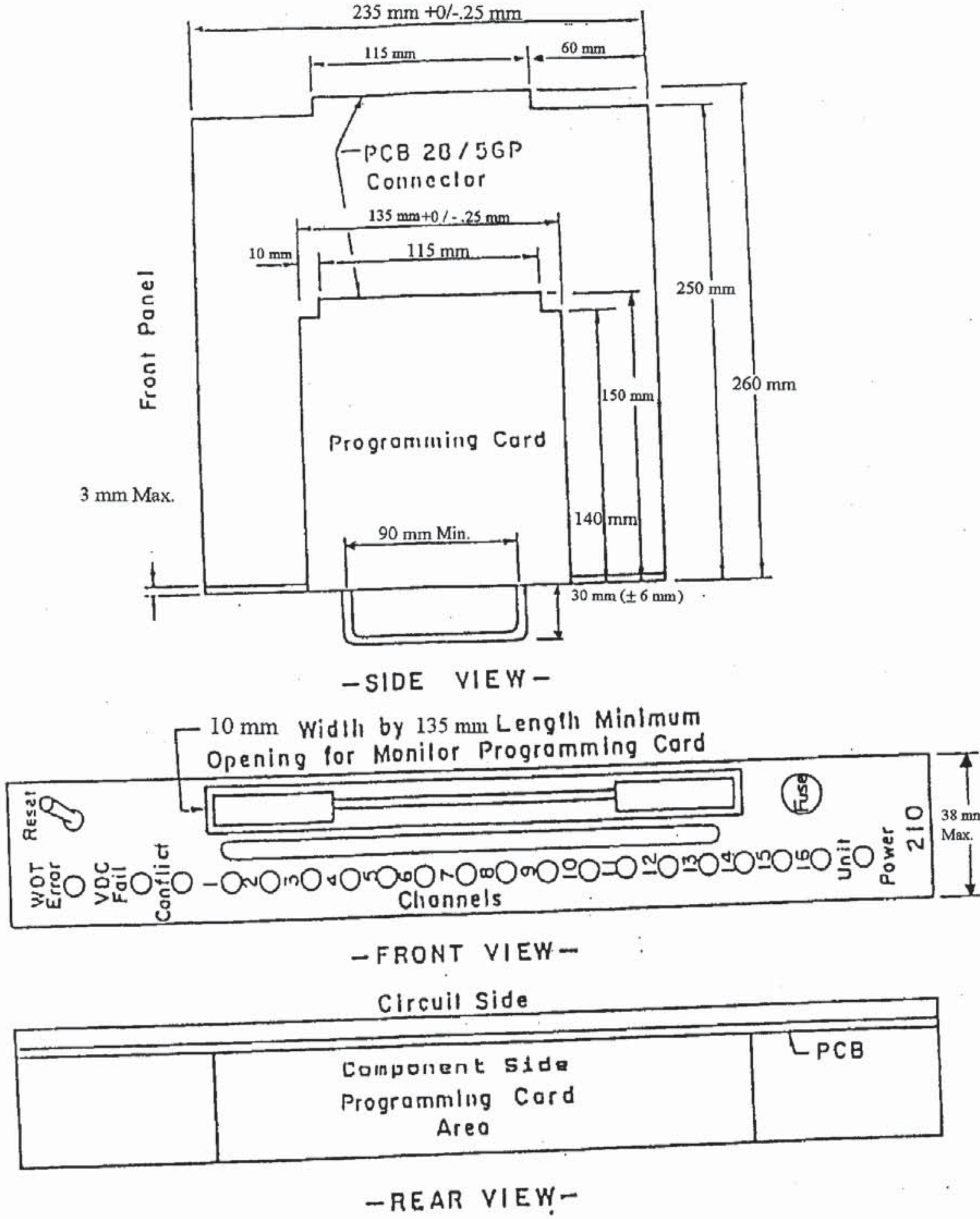


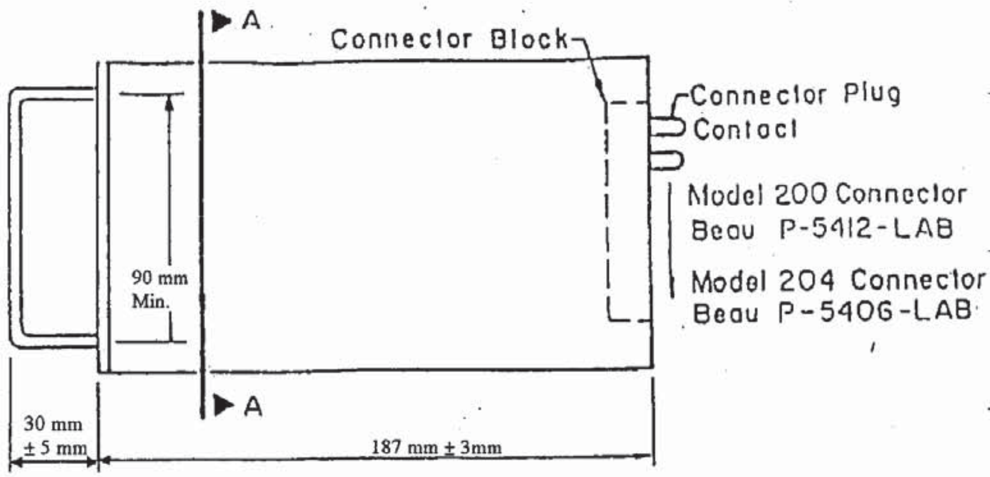
FIGURE 678-6

MODEL 210 CONFLICT-VOLTAGE MONITOR PHYSICAL DETAILS

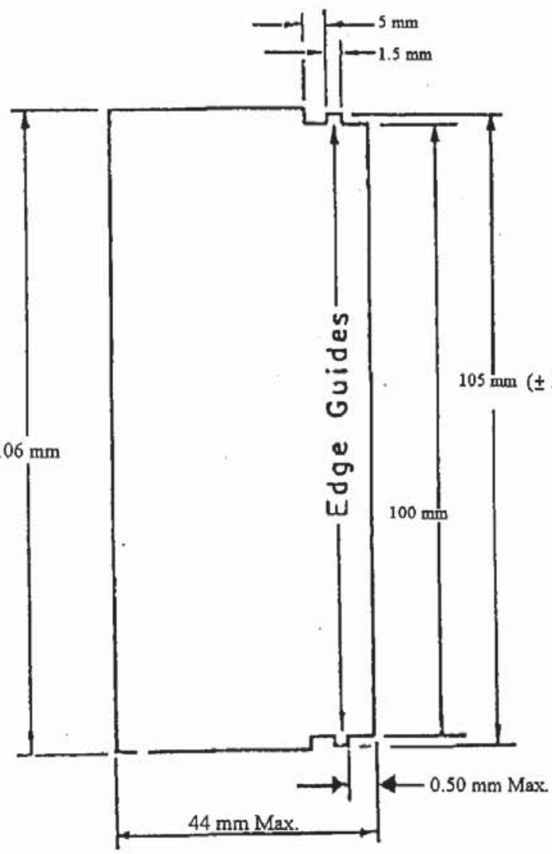


Note: All dimensions are shown in millimeter.

FIGURE 678-7
MODEL 200 SWITCH PACK & MODEL 204 FLASHER DETAILS



—SIDE VIEW—



—CROSS SECTION A-A—

FIGURE 678-8

SWITCH PACK PIN ASSIGNMENTS

PIN NUMBER	FUNCTION
1	120 VAC LINE SIDE
2	CHASSIS GROUND
3	"A" OUTPUT
4	NO CONNECTION
5	"B" OUTPUT
6	"A" INPUT
7	"C" OUTPUT
8	"B" INPUT
9	+24 VOLTS DC
10	"C" INPUT
11	AC COMMON
12	NO CONNECTION

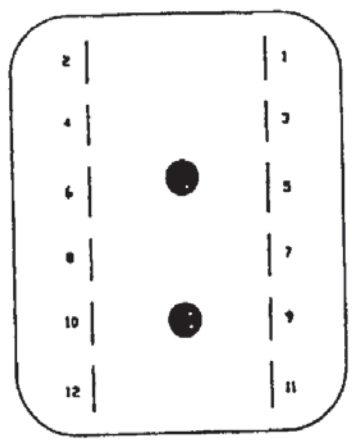


FIGURE 678-9

MODEL 204 FLASHER PIN ASSIGNMENT

PIN NUMBER	FUNCTION
7	Load Circuit 1
8	Load Circuit 2
9	Chassis Ground
10	AC (-) Common
11	AC (+) Hot
12	No Connection

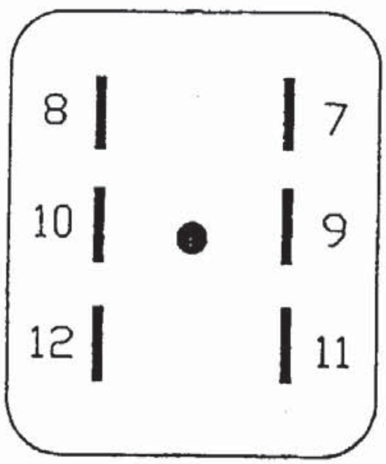
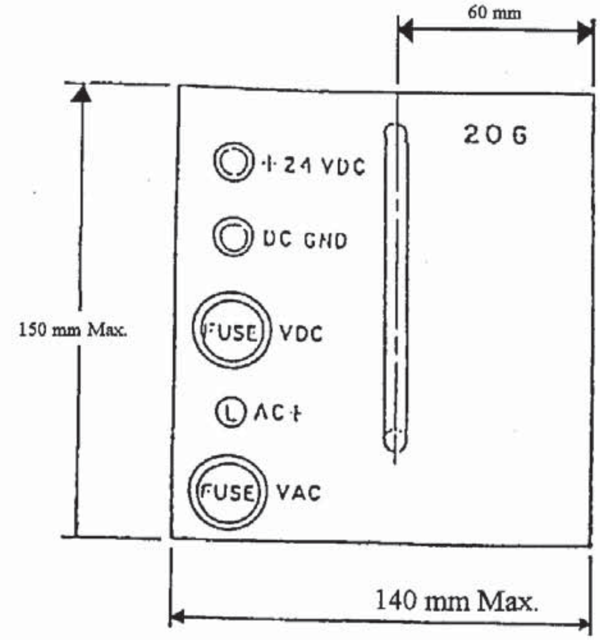
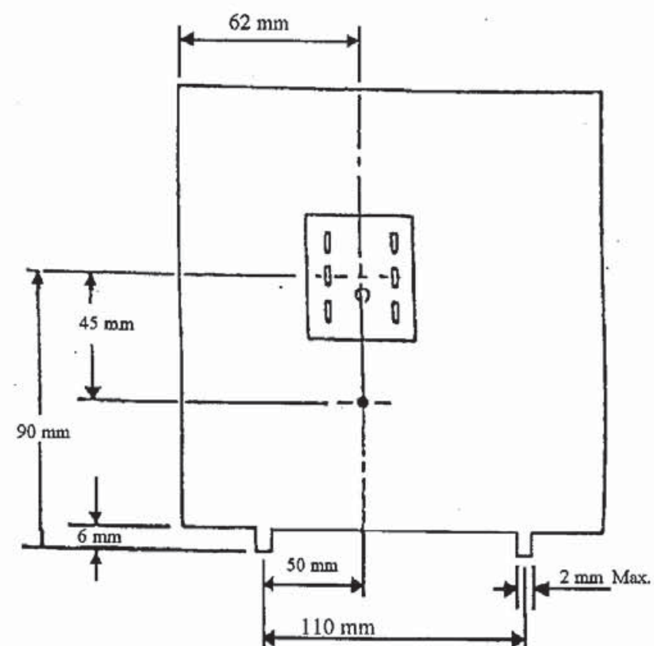


FIGURE 678-10

MODEL 206 POWER SUPPLY MODULE PHYSICAL DETAILS



- FRONT VIEW -

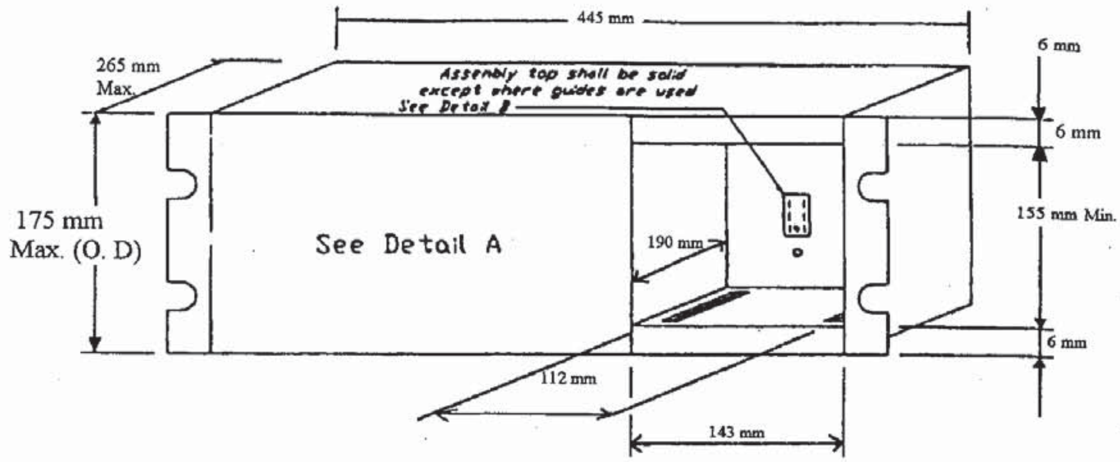


- REAR VIEW -

Note: All dimensions are shown in millimeters.

FIGURE 678-11

POWER DISTRIBUTION ASSEMBLY #2 PHYSICAL DETAILS



- FRONT VIEW -

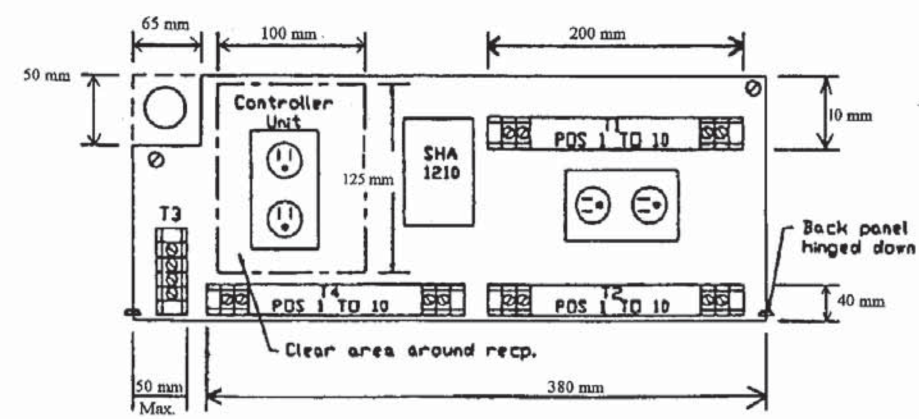


FIGURE 678-12

POWER DISTRIBUTION ASSEMBLY #2 FRONT PANEL DETAILS

-- DETAIL A --

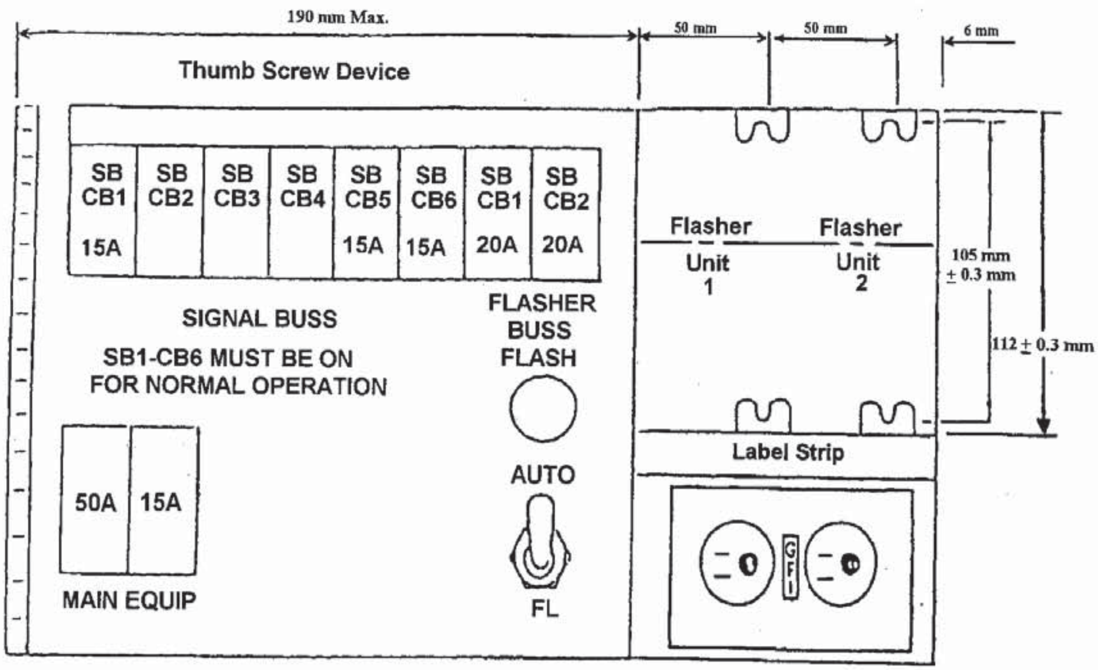
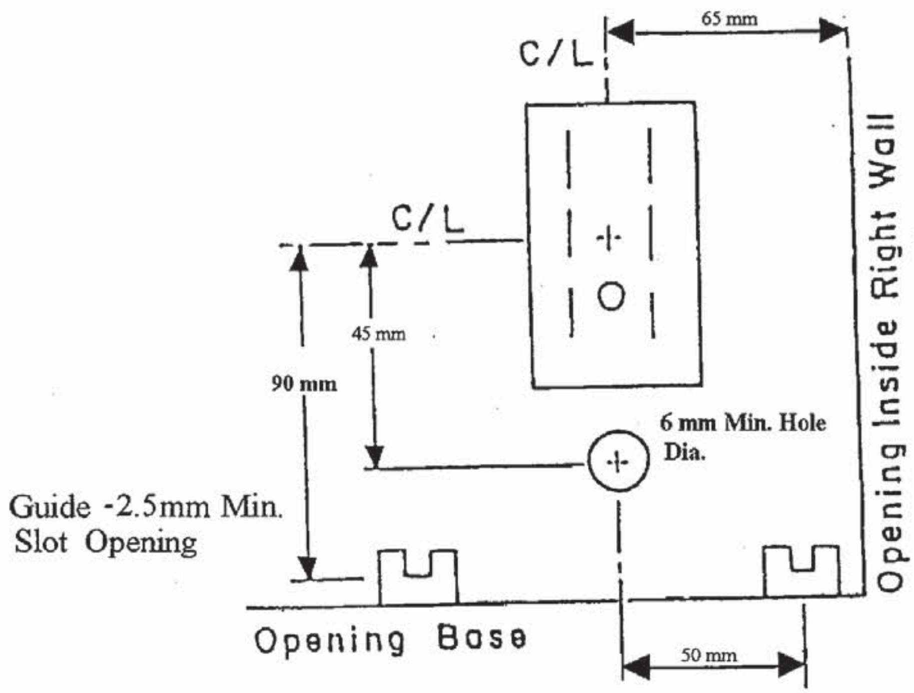


FIGURE 678-13

PDA#2 POWER SUPPLY CONNECTOR/STUD MOUNTING DETAIL

-- DETAIL B --



—DETAIL B—

FIGURE 678-14

PDA #2 INTERCONNECTION WIRING

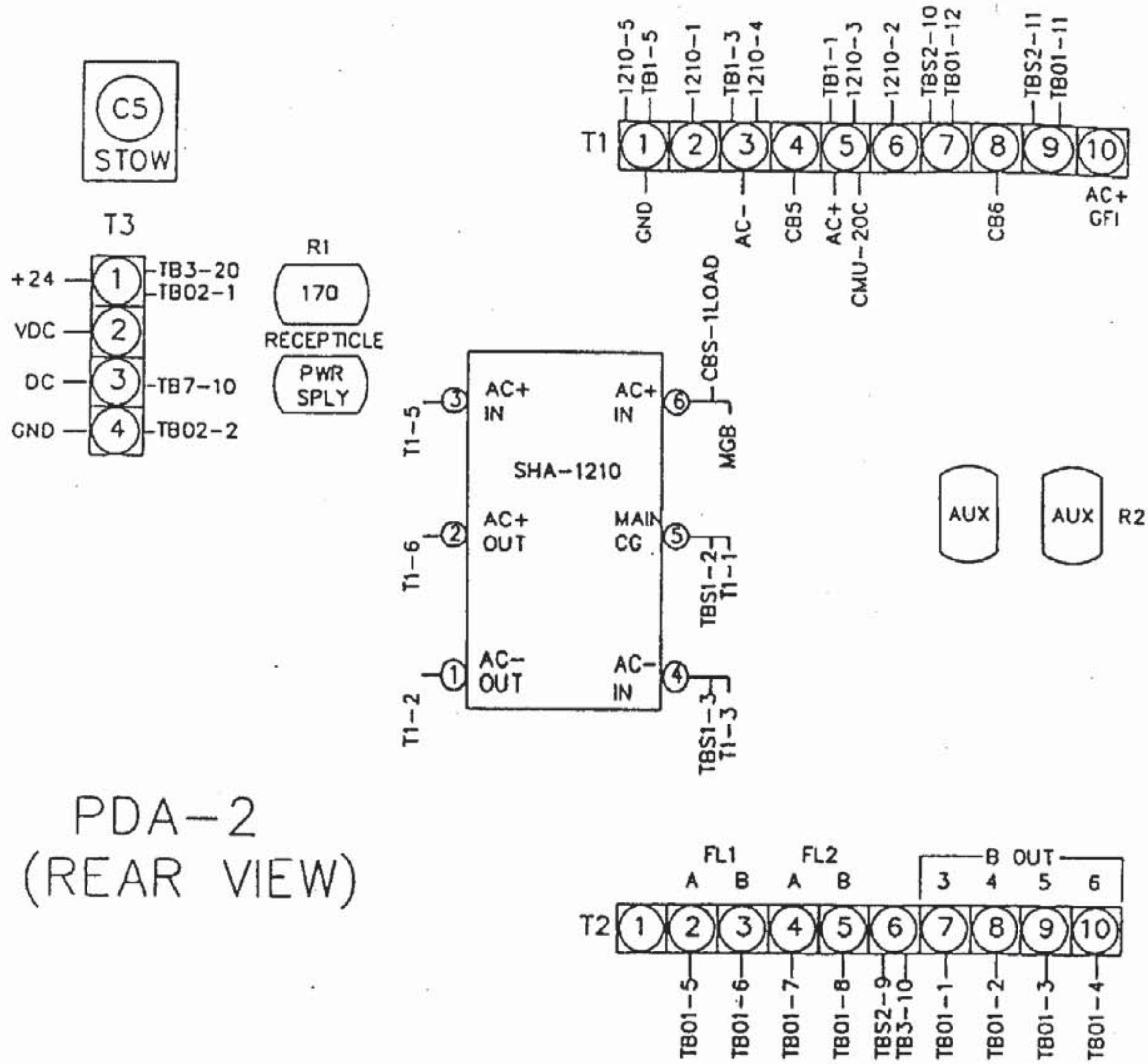


FIGURE 678--15

CIRCUIT BREAKER ONE LINE DIAGRAM

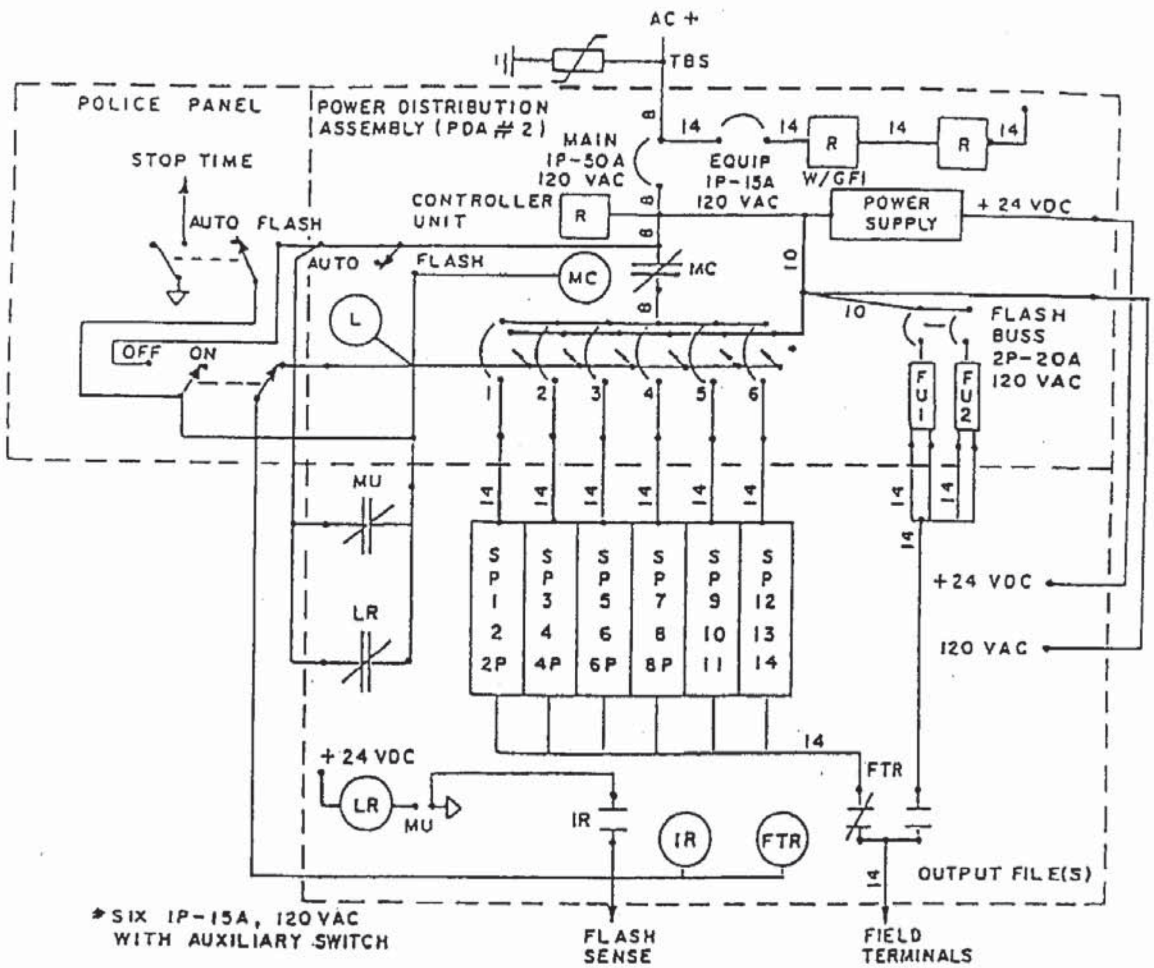
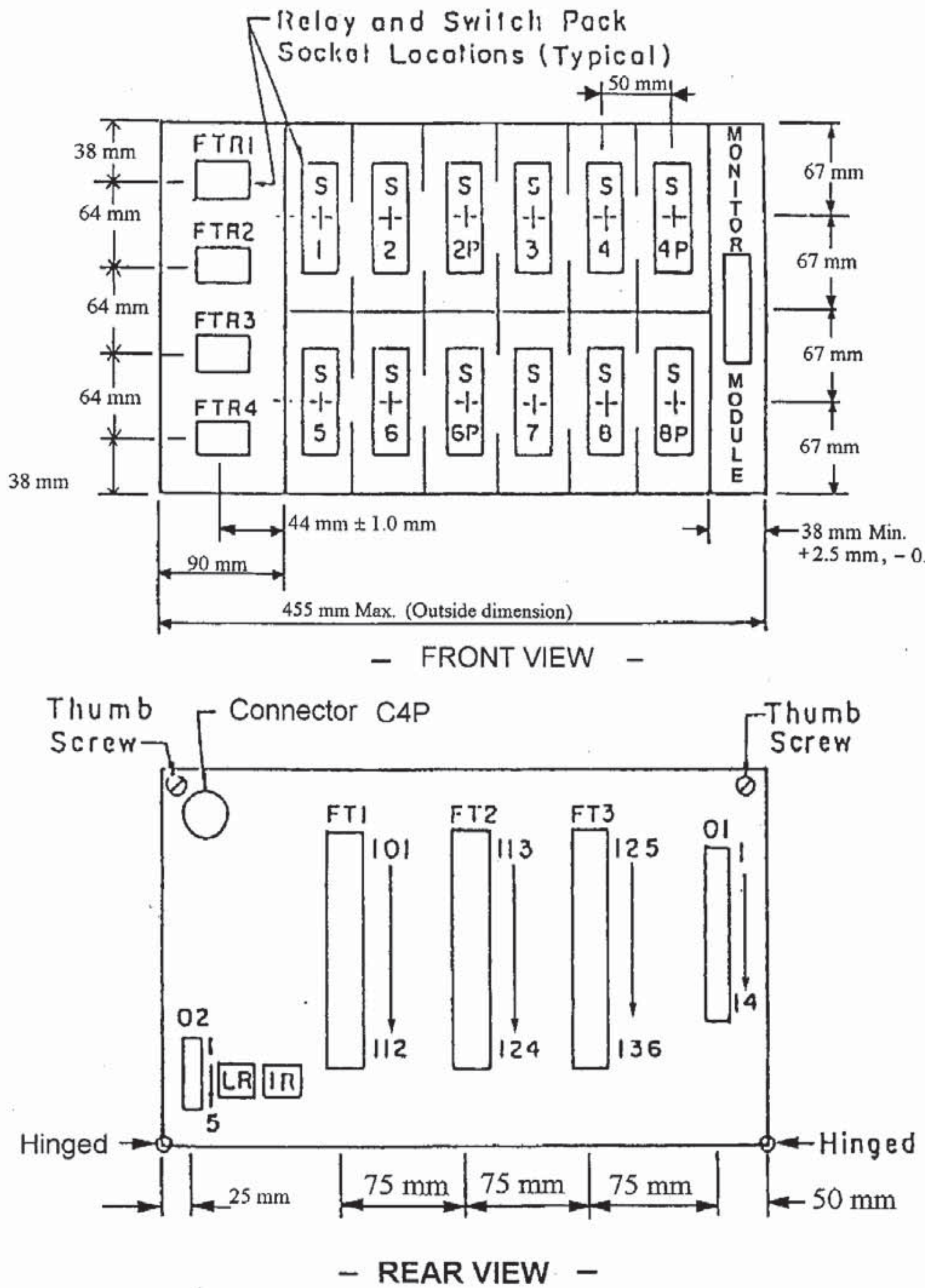


FIGURE 678-16

OUTPUT FILE #1 DETAILS



Note: All dimensions are shown in millilmeter.

FIGURE 678-17

SWITCH PACK MOUNTING DETAIL
(Refer to Figure 678-16 for the overview)

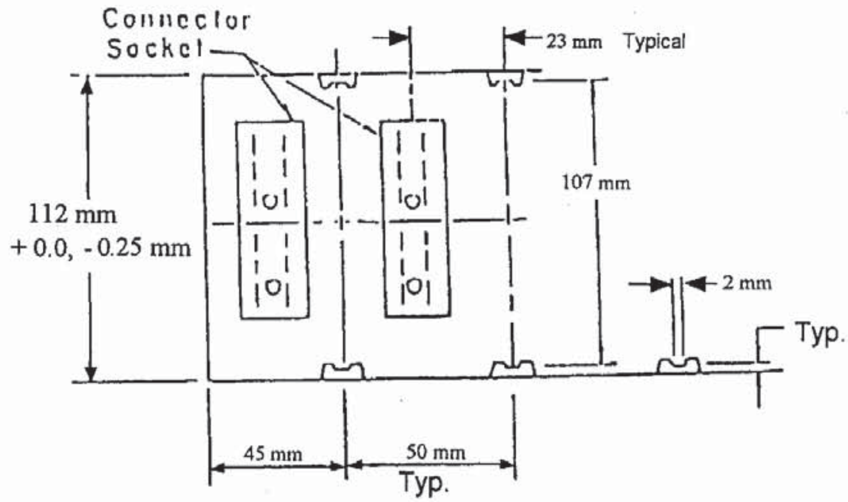


FIGURE 678-18

ISOLATION RELAY DETAIL (IR)
(Refer to 678-16)

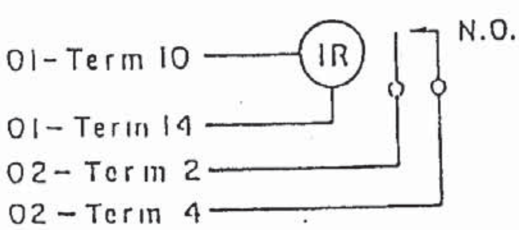


FIGURE 678-19

LOGIC RELAY (LR)
(Refer to 678-16)

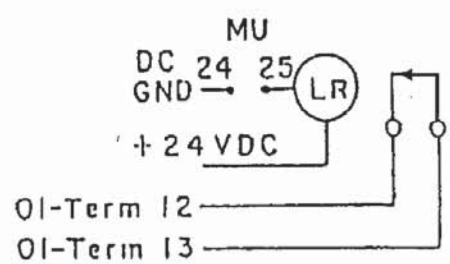
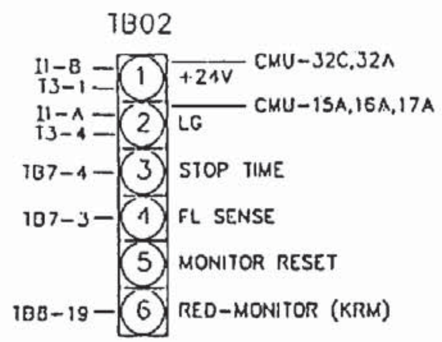
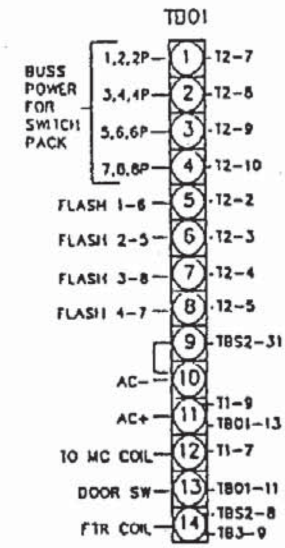


FIGURE 678-20
OUTPUT FILE # 1 INTERCONNECTION WIRING





OUTPUT FILE

FT-1

			FLD	CMU	C1	TBS	TB4
4		R	101	4	4	4-10	
		Y	102	4	5	4-11	
		G	103	4	6	4-12	4
4P		R	104		2	5-4	
	#3←		105		37	5-5	
		G	106	14	3	5-6	10
8		R	107	8	21	4-22	
		Y	108	8	22	4-23	
		G	109	8	23	4-24	8
8P		R	110		19	5-10	
	#7←		111		38	5-11	
		G	112	16	20	5-12	12

FT-2

			FLD	CMU	C1	TBS	TB4
2P		R	113		10	5-1	
	#1←		114	9	35	5-2	
		G	115	13	11	5-3	9
3		R	116	3	7	4-7	
		Y	117	3	8	4-8	
		G	118	3	9	4-9	3
6P		R	119		27	5-7	
	#5←		120		36	5-8	
		G	121	15	28	5-9	11
7		R	122	7	24	4-19	
		Y	123	7	25	4-20	
		G	124	7	26	4-21	7

FT-3

		FLD	CMU	C1	TBS	TB4
1	R	125	1	16	4-1	
	Y	126	1	17	4-2	
	G	127	1	18	4-3	1
2	R	128	2	12	4-4	
	Y	129	2	13	4-5	
	G	130	2	15	4-6	2
5	R	131	5	32	4-13	
	Y	132	5	33	4-14	
	G	133	5	34	4-15	5
6	R	134	6	29	4-16	
	Y	135	6	30	4-17	
	G	136	6	31	4-18	6

FIGURE 678-21
OUTPUT FILE #1 TERMINAL ASSIGNMENTS

TERMINAL TB01	T2	FUNCTION
1	7	PDA CRK 1/SWPKS 1, 2, 2p-1
2	8	PDA CRK 2/SWPKS 3, 4, 4P-1
3	9	PDA CKT 3/SWPKS 5, 6, 6P-1
4	10	PDA SWPKS 7, 8, 8P-1
5	2	PDA FU1 CKT1/FTR1-6
6	3	PDA FU1 CKT1/FTR2-5
7	5	PDA FU2 CKT1/FT3-8
8	5	PDA FU2 CKT2/FTR4-7
9		EQUIPMENT GROUND TBS2-4
10		AC- TB01-9
11		AC+ (FROM PDA) T1-9, TB01-13
12		MC COIL (TO PDA) T-7
13		DOOR SWITCH (FROM POLICE PANEL) TB01-11
14		FTR COILS (TO) TB, TB3-9

TERMINAL TB02	FUNCTION
1	-24 VDC I1-8, T3-1
2	DC GROUND I1-A, T3-4
3	1F1-14J, STOP TIME (FROM MU) TB7
4	1F1-14D, FLASH SENSE (FROM IR) TB7-3
5	EXTERNAL RESET (TO MU)
6	RED MONITOR (KRM) TB8-19

FIGURE 678-22
INTERCONNECT HARNESS OUTPUT FILE #1 TO FIELD SERVICE PANEL

FT TERMINAL OUTPUT FILE #1	SWPK FUNCTION	FIELD SERVICE PANEL TBS
1-101	4-RED	4-10
1-102	4-YELLOW	4-11
1-103	4-GREEN	4-12
1-104	4P-RED	6-4
1-105	4P-Ø 3 ARROW	6-5
1-106	4P-GREEN	6-6
1-107	8-RED	5-10
1-108	8-YELLOW	5-11
1-109	8-GREEN	5-12
1-110	8P-RED	6-10
1-111	8P-Ø7 ARROW	6-11
1-112	8P-GREEN	6-12
2-113	2P-RED	6-1
2-114	2P-Ø 1 ARROW	6-2
2-115	2P-GREEN	6-3
2-116	3-RED	4-7
2-117	3-YELLOW	4-8
2-118	3-GREEN	4-9
2-119	6P-RED	6-7
2-120	6P-Ø 4 ARROW	6-8
2-121	6P-GREEN	6-9
2-122	7-RED	5-7
2-123	7-YELLOW	5-8
2-124	7-GREEN	5-9
3-125	1-RED	4-1
3-126	1-YELLOW	4-2
3-127	1-GREEN	4-3
3-128	2-RED	4-4
3-129	2-YELLOW	4-5
3-130	2-GREEN	4-6
3-131	5-RED	5-1
3-132	5-YELLOW	5-2
3-133	5-GREEN	5-3
3-134	6-RED	5-4
3-135	6-YELLOW	5-5
3-136	6-GREEN	5-6

FIGURE 678-23

MODEL 430 FLASH TRANSFER RELAY CONFIGURATION

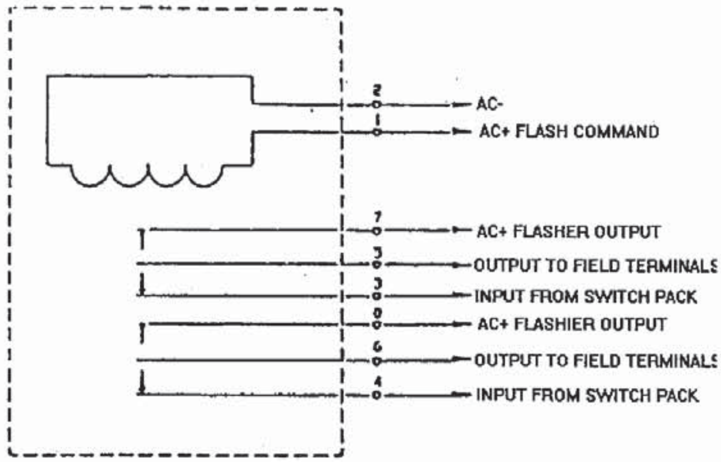
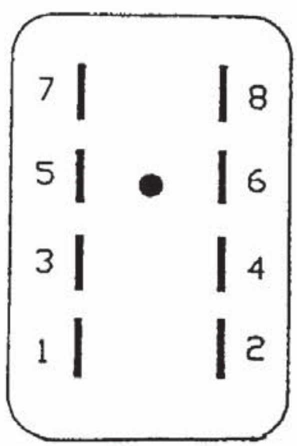


FIGURE 678-24

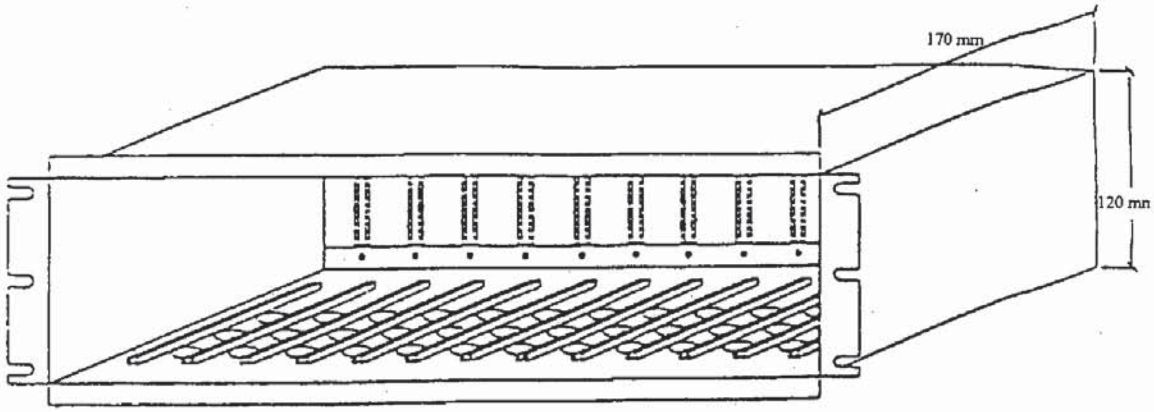
TRANSFER RELAY PIN ASSIGNMENTS



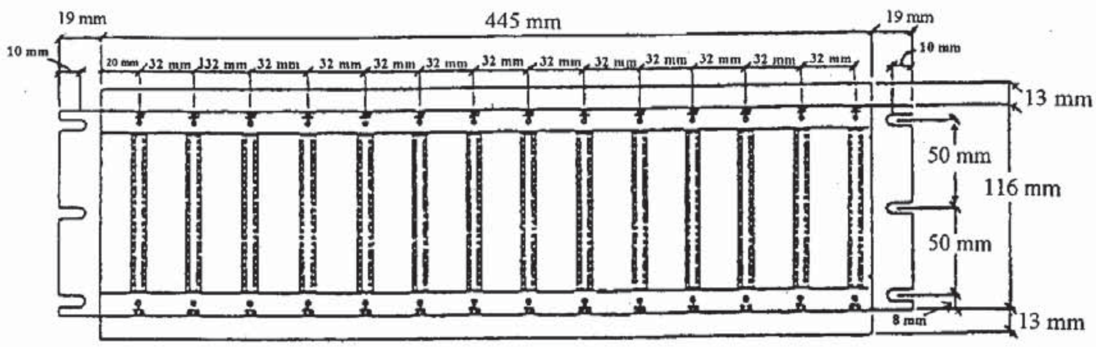
PIN NUMBER	FUNCTION
1	COIL
2	COIL
3	N.C. CIRCUIT #1
4	N.C. CIRCUIT #2
5	COMMON CIRCUIT
6	COMMON CIRCUIT
7	N.O. CIRCUIT #1
8	N.O. CIRCUIT #2

FIGURE 678-25

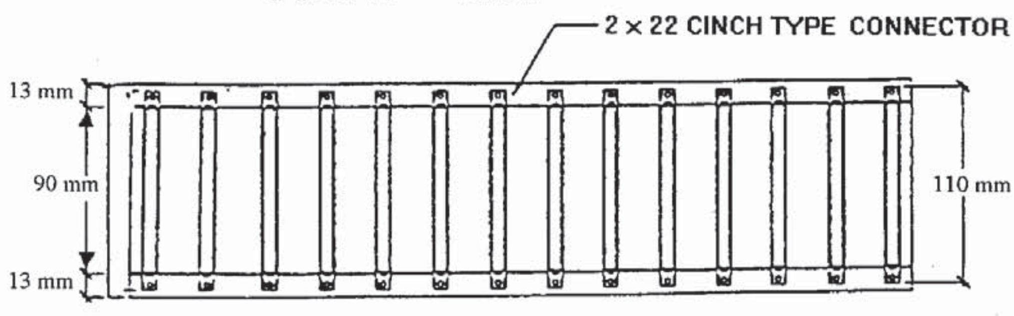
INPUT FILE PHYSICAL DIMENSIONS



- FRONT VIEW -



- FRONT VIEW -



- REAR VIEW -

FIGURE 678-26

CURRENT MONITOR PIN ASSIGNMENTS

CURRENT MONITOR HARNESS (P21)

PIN	FUNCTION	TO
1	HV9 PED 2 YELLOW	114
2	HV8 Ø8 GREEN	109
3	HV7 Ø7 GREEN	124
4	HV6 Ø6 GREEN	136
5	HV5 Ø5 GREEN	133
6	HV4 Ø4 GREEN	103
7	HV3 Ø3 GREEN	118
8	HV2 Ø2 GREEN	130
9	HV1 Ø1 GREEN	127
10	GROUND	CG
11	GROUND	CG
12	CT8 Ø8 ON	107-109
13	CT7 Ø7 ON	122-124
14	CT6 Ø6 ON	134-136
15	CT5 Ø5 ON	131-133
16	CT4 Ø4 ON	101-103
17	CT3 Ø3 ON	116-118
18	CT2 Ø2 ON	128-130
19	CT1 Ø1 ON	125-127
20	SPARE	----
21	HV15 PED 8 GREEN	112
22	HV15 PED 6 GREEN	121
23	HV14 PED 4 GREEN	106
24	HV13 PED 2 GREEN	115
25	HV12 PED 8 YEL	111
26	HV11 PED 5 YEL	120
27	HV10 PED 4 YEL	105
28	GROUND	CG
29	GROUND	CG
30	CT16 PED 8 ON	110 & 112
31	CT15 PED 6 ON	119 & 121
32	CT14 PED 4 ON	104 & 106
33	CT13 PED 2 ON	113 & 115
34	CT12 PED 8 YEL	111
35	CT11 PED 6 YEL	120
36	CT10 PED 4 YEL	105
37	CT9 PED 2 YEL	114

I14

PIN	FUNCTION	TO
A	LOGIC GROUND	D3-A
B	+24 VDC	D3-B
C	RESET	D3-C
D	RS232 TRAN	C21-2
E	RS232 RVC	C21-3
F	FAULT 1 OUT	TB4-17
H	FAULT 1 COM	D4-A
J	RS232 GND	C21-5
K	SPARE	-----
L	CHASSIS GROUND	D3-L
M	AC-	D3-M, TB01-10
N	AC+	D3-N, TB01-11
S	FAULT 3 OUT	TB4-19
T	FAULT 3 COM	D4-H
W	FAULT 2 OUT	TB4-18
X	FAULT 2 COM	D4-T
Y	FAULT 4 OUT	TB4-20
Z	FAULT 4 COM	D4-X