



City of Winnipeg

GENERAL SPECIFICATIONS FOR

TRAFFIC SIGNAL CONTROL EQUIPMENT

September 2010

The City of Winnipeg has been granted permission by California's Department of Transportation to duplicate CALTRANS TRAFFIC SIGNAL CONTROL EQUIPMENT SPECIFICATIONS.

The following technical specifications supplement the requirements of CALTRANS TRAFFIC SIGNAL CONTROL EQUIPMENT SPECIFICATIONS, dated January, 1989 and November, 1993.

1. **PCB Circuit Reference Markings** - PCBs shall have circuit reference symbols clearly and legibly marked by silkscreen, circuit printing or similar permanent marking system on the circuit side, as nearby as practicable to the component referenced. PCB circuit reference symbols shall be identical to those depicted on the pictorial diagram within the manual which shows the physical locations and identification of each component.
This component marking requirement shall apply to all PCBs **except** those within Model 200 Switchpacks and Model 204 Flasher Units. (Reference Item 1.6.1.6 on Page 18 "General Specifications").
2. **PCB Edge Connector Contacts** - all PCB edge connectors shall contain the maximum number of gold-plated contact fingers on both sides of the PCB, including contact fingers for spare and non-assigned connector positions, such that every bifurcated contact within the PCB receptacle (edge-connector) socket makes contact with plated contact fingers on the PCB. (Reference Item 1.2.5.3.6 on Page 12 "General Specifications").
3. **Sensed conflicting** field output **voltages** 25 VAC or greater for a **duration of 250 ms** or longer (**CALTRANS specifies 500 ms**) shall cause a FAILED state. (Reference Item 4.5.1.3 on Page 49 "Model 208/210 Monitors").
4. **Sensed conflicting** field output voltages between 15 and 25 VAC and for **durations between 200 ms and 250 ms** (**CALTRANS specifies 200 and 500 ms**) (Reference Item 4.5.1.4 on Page 50 "Model 208 and 210 Monitors").

The above two Conflict Monitor provisions (3. and 4.) are modified for *Winnipeg application* to permit the Monitor to properly sense flashing field output circuits which flash at a rate greater than 1 Hz, so as to be compatible with "Winnipeg Standard" Model 170E flash rate of **100 flashes per minute** (300 ms ON + 300 ms OFF).
5. Model 336 Cabinets need not be supplied with a "BASE ADAPTER".

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ITEMS SUPPLIED

Items supplied shall be new and unused.

SPECIFICATION PRIORITIES

In case of conflict, the individual chapter shall govern over APPENDIX A and APPENDIX A shall govern over Chapter 1, General Requirements.

CHAPTER 1

GENERAL SPECIFICATIONS FOR TRAFFIC SIGNAL CONTROL EQUIPMENT

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THIS CHAPTER CONTAINS GENERAL REQUIREMENTS APPLICABLE TO ALL EQUIPMENT SPECIFIED IN THIS DOCUMENT.

1.1 SECTION 1 – GLOSSARY

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

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 Adaptor Device, Motorola MC6850 or equal.

ANSI - American National Standards Institute.

Assembly - A complete machine, structure or unit of a machine that was manufactured by fitting together parts and/or modules.

ASTM - American Society for Testing and Materials.

AWG - American Wire Gauge.

C - Celsius

Cabinet - An outdoor enclosure for housing the controller unit and associated equipment.

Caltrans – California Department of Transportation

Certificate of Compliance - A certificate signed by the manufacturer of the material or the manufacturer of assembled materials stating that the materials involved comply in all respects with the requirements of the specifications.

Channel - An information path from a discrete input to a discrete output.

CITY - The City of Winnipeg, Province of Manitoba, Canada. The City of Winnipeg Public Works Department, Transportation Division, Traffic Signal Systems Branch.

CMOS - Complementary Metal Oxide Semiconductor.

Component - A component shall be identified as any electrical or electronic device.

Contractor - The person or persons, manufacturer, firm, partnership, corporation, vendor or combination thereof, who have entered into a contract with the CITY, as party or parties of the second part or his or their legal representative.

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.

CR - ACIA Control Register.

CSA - Canadian Standards Association.

DAT Program - The State of California Department of Transportation's Diagnostic and Acceptance Test Program.

DC - Direct Current.

DTA - Down Time Accumulator.

dB - Decibel.

dBa - Decibels above reference noise, adjusted.

deg – Degrees.

EG - Equipment Ground.

EIA - Electronic Industries Association.

Engineer - The Manager of the Traffic Signal Systems Branch of the CITY of Winnipeg, acting either directly or through properly authorized agents, such agents acting within the scope of the particular duties delegated to them.

EPROM - Ultraviolet Erasable Programmable Read Only Memory Device.

Equal - Connectors: complying to physical dimensions, contact/pin material, plating and method of connection. Devices: conforming to function, pin out, electrical and operating parameter requirements, access times and interface parameters of the specified device. Interpretation shall be in the judgment of the Engineer.

ETL - Electrical Testing Laboratories, Inc.

HEX - Hexadecimal.

Hz - Hertz.

I.D. - Identification.

Jumper - A means of connecting/disconnecting two or more conductive points by soldering/desoldering a conductive wire jumper.

Laboratory (Shop) - The established Maintenance Shop of the City of Winnipeg Traffic Signals Assets Branch of the Transportation Division; or other laboratories authorized by the Department to test materials involved in the contract.

LED - Light Emitting Diode.

mA - Milliampere.

MIC - Hitachi HD6303X microprocessor device (or equal).

MODEM - Modulate/Demodulate Unit.

Module - A functional unit that plugs into an assembly.

Motherboard - A printed circuit connector interface board with no active or passive components.

MOS - Metal Oxide Semiconductor.

MPU - Motorola 6800 microprocessor device (or equal).

ms - Millisecond.

mW - Milliwatt.

M/170E - Program Module/Model 170E Controller Unit Connector.

NA - Presently Not Assigned. Cannot be used by the contractor for other purposes.

NEMA - National Electrical Manufacturer's Association.

NETA - National Electrical Testing Association, Inc.

N.C. - Normally closed contact.

N.O. - Normally open contact.

ns - Nanosecond.

PLA/PAL - Programmable Array Logic Device.

PCB - Printed Circuit Board.

RDR - ACIA Receiver Data Register.

ROM - Read Only Memory Device.

RTC - Model 170E Controller Unit Real Time Clock. This circuitry provides a 170E CPU IRQ interrupt pulse clocked off of the local power company's line frequency every 16.67 ms.

RTCA - Real Time Clock Adjustor Circuitry.

RTS - Request to Send.

R/W - Model 170E Controller Unit Read/Write Control Line.

SCI - Serial Communications Interface.

Second Sourced - Produced by more than one manufacturer.

SR - ACIA Status Register.

SRAM - Static Random Access Memory Device.

STATE - State of California

SW - Switch.

TDR - ACIA Transmit Data Register.

Thumbscrew Device - An 8-32 retractable screw fastener with projecting stainless steel screw, spring and natural aluminum knob finish (SOUTHCO #47-62-301-XX or equal).

TTL - Transistor-Transistor Logic.

uA - Microampere.

UL - Underwriter's Laboratories, Inc.

us - Microsecond.

VAC - Voltage Alternating Current.

VDC - Voltage Direct Current.

VMA - Valid Memory Address.

Watchdog Timer (WDT) - A monitoring circuit, external to the Controller Unit, which senses a Controller Unit Output Line.

XX - Manufacturer's Option.

1.2 SECTION 2 – GENERAL

1.2.1 All equipment furnished under these specifications shall be of the solid state design. Use of vacuum or gaseous tubes or electro-mechanical devices within the equipment is not acceptable unless otherwise indicated.

1.2.2 Documentation

1.2.2.1 Two manuals shall be supplied with each item up to a maximum of five (5) manuals.

1.2.2.2 Manuals shall be printed on 8.5 by 11 inch paper. Schematics, layouts, parts lists and plan details may be on 11 by 17 inch sheets, but the sheets must be neatly folded to 8.5 by 11 inch size. The manual shall be bound in durable covers.

1.2.2.3 Each manual shall include the following:

- General Description
- General Characteristics
- Installation
- Adjustments
- Theory of Operation
 1. Systems Description (include block diagram).
 2. Detailed Description of Circuit Operation.
- Maintenance
 1. Preventative Maintenance.
 2. Trouble Analysis.
 3. Trouble Shooting Sequence Chart.
 4. Wave Forms
 5. Voltage Measurements.
 6. Alignment Procedures.
- Parts List (to include circuit and board designation, part type and class, power rating and component manufacturer and original manufacturer's part number).
- Electrical Interconnection Drawing.
- Schematic and Logic Diagram.
- Assembly drawings and a pictorial diagram showing physical locations and identification of each component.
- The serial numbers and revision numbers of equipment covered by manuals shall be printed on the front cover of the manuals.

1.2.2.4 Manuals for the Model 170E Controller Unit, Models 332, 334 and 336 Cabinets shall be furnished with the item and enclosed in the shipping container.

1.2.2.5 Prior to final printing, a preliminary draft of all manuals shall be submitted to the Engineer for approval.

1.2.3 Interchangeability - The following assemblies and their respective associated devices shall electrically and mechanically intermate and be compatible with each other:

ASSEMBLIES

Output File #1 and #2

ASSOCIATED DEVICES

Model 200 Switch Pack
Model 210 Monitor Unit
Model 430 Heavy Duty Relay

Input File	Models 222, 224 and 232 Detectors Models 242 and 252 Isolators
Power Distribution Assembly #1 and #2	Model 204 Flasher Unit Model 206 Power Supply Module Model 430 Heavy Duty Relay
Power Distribution Assembly #3	Model 200 Switch Pack Model 206 Power Supply Module Model 208 Monitor Unit Model 430 Heavy Duty Relay
Model 170E Controller Unit	Cabinet Models 332, 334 and 336 Model 400 MODEM Model 412C Program Module
Auxiliary Output File, Model 420	Model 200 Switch Pack Model 430 Heavy Duty Relay

1.2.4 Indicators and Character Displays

1.2.4.1 All indicators and character displays shall have a ± 45 degrees cone of visibility with its axis perpendicular to the front panel. All indicators and character displays shall be readily visible at a radius of up to 4 feet within the cone of visibility when the indicator is subjected to 9,000 foot candles of white light with the light source at $45 (\pm 2)$ degrees to the front panel. If characters are not self-luminous, illumination shall be provided for viewing in low levels of ambient light. Indicators supplied on equipment requiring handles shall be mounted such that a horizontal clearance of 15 degrees minimum shall be provided for Models 208, 210, 222, 232, 242 and 252, and also a clearance of 30 degrees minimum shall be provided for Models 200, 204 and 206.

1.2.4.2 All indicators and character displays shall have a rated life of 100,000 hours, minimum.

1.2.4.3 Liquid Crystal Displays (LCD) shall operate at temperatures of -30 degrees to +70 degrees C without loss of visibility or bleeding.

1.2.5 Connectors

1.2.5.1 General

- 1.2.5.1.1 All connectors shall be keyed to prevent improper insertion of the wrong connector or PCB.
- 1.2.5.1.2 The TYPE 25 Connector shall be a 25 contact AMP HDP-20 Connector or equal with gold on nickel plated contacts. The female mating connector with socket contacts is designated TYPE 25S and the male mating connector with pin contacts is designated TYPE 25P. The TYPE 25P Connector shall be provided with lock spring clips for latching to its mating connector.
- 1.2.5.1.3 The TYPE T Connector shall be a single row, 10 position, feed through terminal block. The terminal block shall be a barrier type with 6-32, 0.25 inch, or longer, nickel plated brass binder head screws. Each terminal shall be permanently identified as to its function.
- 1.2.5.1.4 The mating connectors shall be designated as the connector number and male/female relationship such as C1P (plug or PCB edge connector) and C1S (socket).

1.2.5.2 Connectors C1, C2, C4, C5 and C6

1.2.5.2.1 Pin and socket contacts for Connectors C1, C2, C4, C5 and C6 shall be beryllium copper construction sub plated with 0.00005 inch nickel and plated with 0.00003 inch gold. Pin diameter shall be 0.062 inch. Connectors shall have the following number of contacts:

C1 - 104 contacts	C4 - 37 contacts
C2 - 14 contacts	C5 & C6 - 24 contacts

1.2.5.2.2 All pin and socket connectors of C1, C2, C4, C5 and C6 shall use the AMP #601105-1 or #91002-1 contact insertion tool, and the AMP #305183 contact extraction tool.

1.2.5.2.3 Connector C1 and C2 blocks shall be constructed of phenolic or equal and shall have an insulation resistance of 5000 megohms. The contacts shall be secured in the blocks with stainless steel springs.

1.2.5.2.4 Connector C1 and C2 corner guides shall be stainless steel. The guide pins shall be 1.097 inches in length and the guide sockets 0.625 inch in length.

1.2.5.2.5 Connector C4, C5 and C6 shall be circular plastic type with quick connect/disconnect capability and thread assist, positive detent coupling. The connectors shall be UL listed Glass Filled Nylon, 94 V-I Rated, heat stabilized, fire resistant.

1.2.5.3 PCB Connectors

1.2.5.3.1 PCB edge connectors shall have bifurcated gold plated contacts.

1.2.5.3.2 The PCB connector shall meet or exceed the following:

Operating Voltage: 600 VAC (RMS) at sea level
 Current Rating: 5 amperes
 Insulation Resistance: 5,000 megohms
 Contact Material: Copper alloy plated with 0.00005 inch of nickel and 0.000015 inch of gold
 Contact Resistance: 0.006 ohm maximum

1.2.5.3.3 The PCB 22/44 Connector shall have 22 independent contacts per side, dual sided with 0.156 inch contact centres.

1.2.5.3.4 The PCB 28/56 Connector shall have 28 independent contacts per side, dual sided with 0.156 inch contact centres.

1.2.5.3.5 The PCB 36/72 Connector shall have 36 independent contacts per side, dual sided with 0.1 inch contact centres.

1.2.5.3.6 **PCB Edge Connector Contacts - all PCB edge connectors shall contain the maximum number of gold-plated contact fingers on both sides of the PCB, including contact fingers for spare and non-assigned connector positions, such that every bifurcated contact within the PCB receptacle (edge-connector) socket makes contact with plated contact fingers on the PCB.**

1.2.6 Packaging - Each item delivered shall be individually packed in its own shipping container. When loose Styrofoam is used for packing, the item shall be sealed in a plastic bag to prevent

direct contact with the Styrofoam.

1.2.7 Delivery - Each item delivered for testing shall be complete, including manuals, and ready for testing.

1.2.8 Metals

1.2.8.1 Aluminum

1.2.8.1.1 Sheet shall be Type 5052-H32 ASTM Designation B209.

1.2.8.1.2 Rod, Bar and Extruded shall be Type 6061-T6, or equal.

1.2.8.2 Stainless Steel sheet shall be annealed or one-quarter-hard complying with the ASTM Designation: A666 for Type 304, Grades A or B, stainless steel sheet.

1.2.8.3 Cold Rolled Steel

1.2.8.3.1 Sheet, Rod, Bar and Extruded shall be Type 1018/1020.

1.2.8.3.2 Plating - All cold roll steel shall be plated. All plating shall be either cadmium plating meeting the requirements of U.S. Federal Specification QQ-P-416C, Type 2 Class 1 or zinc plating meeting the requirements of Federal Specification QQ-Z-325B, Type 2 Class 1.

1.2.8.4 All sharp edges and corners shall be rounded.

1.3 SECTION 3 – COMPONENTS

1.3.1 All components shall be second sourced and shall be of such design, fabrication, nomenclature, or other identification as to be purchased from a wholesale electronics distributor, or from the component manufacturer, except as follows:

1.3.1.1 When a component is of such special design that it precludes the purchase of identical components from any wholesale electronics distributor or component manufacturer, one spare duplicate component shall be furnished with each 20, or fraction thereof, components used.

1.3.1.2 Circuit design shall be such that all components of the same generic type, regardless of manufacturer, shall function equally in accordance with the specifications.

1.3.2 Only Memory, MPU, MIC and ACIA devices shall be socket mounted on the PCB's.

1.3.3 No component shall be operated above 80% of its maximum rated voltage, current or power ratings. Digital components shall not be operated above 3% over their nominal voltage, current or power ratings.

1.3.4 No component shall be provided where the manufactured date is 2 years older than the contract award date. The design life of all components, operating for 24 hours a day operating in their circuit application, shall be 10 years or longer.

1.3.5 Encapsulation of 2 or more discrete components into circuit modules is prohibited, except for transient suppression circuits, resistor networks, diode arrays, solid state switches, optical isolators and transistor arrays.

1.3.6 Except as specified in 1.3.5, all discrete components, such as resistors, capacitors, diodes,

transistors, and integrated circuits shall be individually replaceable. Components shall be arranged so they are easily accessible for testing and maintenance.

1.3.7 The Contractor shall submit detailed engineering technical data on all components at the request of the Engineer. A letter from the component manufacturer shall be submitted with the detailed engineering data when the proposed application of the component alters the technical data. The letter shall certify that the component application meets specification requirements.

1.3.8 Capacitors

1.3.8.1 The DC and AC voltage ratings as well as the dissipation factor of a capacitor shall exceed the worst case design parameters of the circuitry by 150%.

1.3.8.2 A capacitor which may be damaged by shock or vibration shall be supported mechanically by a clamp or fastener.

1.3.8.3 Capacitor encasements shall be resistant to cracking, peeling and discolouration.

1.3.8.4 All capacitors shall be insulated and shall be marked with their capacitance value and working voltage.

1.3.8.5 Electrolytic capacitors shall not be used for capacitance values of less than 1.0 microfarad and shall be marked with polarity.

1.3.9 Potentiometers

1.3.9.1 Potentiometers with ratings from 1 to 2 watts shall be equivalent to U.S. Military Type RV4.

1.3.9.2 No potentiometers less than 1 watt rating shall be used (except for trimmer type function).

1.3.9.3 The power rating of any potentiometer shall be at least 100% greater than the maximum power requirements of the circuit.

1.3.10 Resistors

1.3.10.1 Fixed carbon film, deposited carbon, or composition insulated resistors shall conform to the performance requirement of U.S. Military Specifications: MIL-R-11F or MIL-R-22684.

1.3.10.2 All resistors shall be insulated and shall be marked with their resistance value. Resistance values shall be indicated by the EIA colour codes.

1.3.10.3 Resistors shall be 10% or less tolerance.

1.3.10.4 The value of the resistors shall not vary by more than 5% between -37 degrees C and +74 degrees C.

1.3.10.5 Resistors that have a rating exceeding 2 watts shall not be used unless special ventilation or heat sinking is provided. They shall be insulated from the PCB.

1.3.11 Semiconductor Devices

1.3.11.1 All solid state devices, except LED's, shall be of the silicon type.

1.3.11.2 All transistors, integrated circuits, and diodes shall be a standard type listed by EIA

and clearly identifiable.

1.3.11.3 All metal oxide semiconductor components shall contain circuitry to protect their inputs and outputs against damage due to high static voltages or electrical fields.

1.3.11.4 The device pin "1" location shall be properly marked on the PCB adjacent to each pin.

1.3.12 Transformers and Inductors

1.3.12.1 All power transformers and inductors shall have the manufacturer's name or logo and part number clearly and legibly printed on the case or laminations.

1.3.12.2 All transformers and inductors shall have their windings insulated and shall be protected to exclude moisture.

1.3.12.3 All transformer and inductor leads shall be color coded with an approved EIA color or identified such to facilitate proper installation.

1.3.13 Circuit Breakers (10 amperes or greater)

1.3.13.1 Circuit breakers shall be listed by UL or ETL. The trip and frame sizes shall be plainly marked (marked on the breaker by the manufacturer), and the ampere rating shall be visible from the front of the breaker. All circuit breakers (30 amperes or greater) shall be quick-break on either automatic or manual operation. Contacts shall be silver alloy and enclosed in an arc quenching chamber. Overload tripping shall not be influenced by an ambient air temperature range of from -18 to 50 degrees C. Minimum interrupting capacity shall be 5,000 amperes, RMS.

1.3.13.2 Circuit breakers shall be the trip-free type.

1.3.13.3 Multi-pole breakers shall be the common-trip type.

1.3.14 Switches

1.3.14.1 DIP - Dual-in-package, quick snap switch(es) shall be rated for a minimum of 30,000 operations per position at 50 ma, 30 VDC. The switch contact resistance shall be 100 milliohms maximum at 2 ma, 30 VDC. The contacts shall be gold over brass (or silver).

1.3.14.2 LOGIC - The switch contacts shall be rated for a minimum of one ampere resistive load at 120 VAC or 28 VDC and shall be silver over brass (or equal). The switch shall be rated for a minimum of 40,000 operations.

1.3.14.3 CONTROL - The switch contacts shall be rated for a minimum of five amperes resistive load at 120 VAC or 28 VDC and shall be gold over brass (or equal). The switch shall be rated for a minimum of 40,000 operations.

1.3.14.4 POWER - Ratings shall be same as CONTROL except that the contact rating shall be a minimum of ten amperes at 125 VAC.

1.4 SECTION 4 – MECHANICAL

1.4.1 Assemblies and PCB Design

1.4.1.1 Assemblies (including Controller Unit) -- All assemblies shall be easily replaceable and incorporate plug-in capability for their associated devices or PCB's with the following

exceptions:

- The cabinet power supply.
- Mother board assemblies.
- The power supply for the Model 170E may be a plug-in assembly.

1.4.1.2 Assemblies shall be provided with 2 guides for each plug-in PCB or associated device (except relays). The guides shall extend to within 0.75 inch from the face of either the socket or connector and front edge of the assembly. If Nylon guides are used, the guides shall be securely attached to the file or assembly chassis. All printed circuit boards shall be mounted vertically.

1.4.1.3 PCB -- No components, traces, brackets or obstructions shall be within 0.125 inch of the board edge (guide edges).

1.4.1.4 The manufacturer's name or logo, model number, serial number, and circuit issue or revision number shall appear and be readily visible on all items. Placement of this information for modules such as the Model 208 or 210 Monitor Units, Model 400 MODEM, Model 412C Program Module and Model 414 Program Module shall be on the PCB.

1.4.2 Workmanship - Workmanship shall be in accordance with the highest industry standards.

1.4.3 Model Numbers

1.4.3.1 The manufacturer's model number, serial number and circuit issue or revision number shall appear on the rear panel of all equipment and modules supplied.

1.4.3.2 In addition to any assignment of model numbers by the manufacturer, a model number assigned in the table below shall be displayed on the front panel in bold type, at least 0.25 inch high.

MODEL#	TITLE
170E	CONTROLLER UNIT
200	SWITCHPACK
204	FLASHER UNIT
206	POWER SUPPLY MODULE
208	MONITOR UNIT
210	MONITOR UNIT
222	LOOP SENSOR UNIT
224	LOOP SENSOR UNIT
231	MAGNETIC ELEMENT
232	MAGNETIC SENSOR UNIT
242DC	ISOLATOR
252AC	ISOLATOR
402	SUPPORT ASSEMBLY
412C	PROGRAM MODULE

1.4.4 All PCB connectors mounted to the motherboard shall be mechanically secured to the chassis or frame of the unit.

1.4.5 All screw type fasteners shall utilize locking devices or locking compounds except for finger screws which shall be captive.

- 1.4.6 Tolerances - The following tolerances shall apply, except as specifically shown on the plans or in these specifications:

Sheet Metal ± 0.0525 inch / PCB+ 0, -0.10 inch / Edge Guides ± 0.015 inch

1.5 SECTION 5 – ENGINEERING

1.5.1 Human Engineering

- 1.5.1.1 To the highest practicable degree, the unit shall be engineered for simplicity and ease of operation and maintenance. This shall include the following:

- 1.5.1.1.1 No more than 2 potentiometers, controls or switches may be mounted concentrically. Knobs for such devices shall have diameters in a ratio of 2:1 outer to inner. The outer knob shall have a diameter of at least one inch.
- 1.5.1.1.2 Knobs shall be of large enough diameter (at least 0.5 inch diameter) and of great enough separation (at least 0.5 inch edge to edge) to assure ease of adjustment without disturbance of adjacent knobs.
- 1.5.1.1.3 All fuses shall be easily accessible and shall be replaceable without the use of any tools.
- 1.5.1.1.4 PCB's shall slide smoothly in their guides while being inserted into or removed from the frame and shall fit snugly into the plug-in PCB connectors.
- 1.5.1.1.5 PCB's shall require a force no less than 5 pounds or greater than 50 pounds for insertion or removal.

1.5.2 Design Engineering

- 1.5.2.1 The following practices shall be employed in the design of solid state equipment circuitry:

- 1.5.2.1.1 The design shall be inherently temperature compensated to prevent abnormal operation. The circuit design shall include such compensation as is necessary to overcome adverse effects due to temperature in the specified environmental range.
- 1.5.2.1.2 For reasons of personal safety, personnel shall be protected from all dangerous voltages.

- 1.5.3 Generated Noise - No item, component or subassembly shall emit a noise level exceeding the peak level of 55 dBA when measured at a distance of one meter away from its surface.

1.6 SECTION 6 - PRINTED CIRCUIT BOARDS

1.6.1 Design, Fabrication and Mounting

- 1.6.1.1 All contacts on PCB's shall be plated with a minimum thickness of 0.000030 inch gold over a minimum thickness of 0.000075 inch nickel.
- 1.6.1.2 PCB design shall be such that components may be removed and replaced without damage to boards, traces or tracks.
- 1.6.1.3 Fabrication of PCB's shall be in compliance with U.S. Military Specification: MIL-P-13949,

except as follows:

- 1.6.1.3.1 Only NEMA glass cloth base epoxy resin copper clad laminates 0.0626 inch minimum thickness shall be used. Intercomponent wiring shall be by laminated copper clad track having a minimum weight of 2 ounces per square foot with adequate cross section for current to be carried. All copper tracks shall be plated or soldered to provide complete coverage of all exposed copper track. Jumper wires will not be permitted, except from plated-through padded holes to an external component or for designed function selection with the jumper insulated and as short as possible.
- 1.6.1.3.2 Section 3.3.3 of U.S. Military Specification: MIL-P-13949E shall read "Pits and Dents. Grade of Pits and Dents shall be of Grade B quality (3.3.3.2) or better."
- 1.6.1.3.3 Section 3.3 of Military Specification: MIL-P-13949 shall be omitted.
- 1.6.1.3.4 Section 3.4 of Military Specification: MIL-P-13949 shall read "Warp or Twist. Class of permissible warp or twist shall be Class A (Table II) or better."
- 1.6.1.3.5 Sections 4.2 through 6.6 of Military Specification: MIL-P-13949 (inclusive) shall be omitted except as referenced in previous sections of this specification.
- 1.6.1.4 The fabrication of PCB's and the mounting of parts and assemblies thereon shall conform to U.S. Military Specification: MIL-STD-275E, except as follows:
 - 1.6.1.4.1 All semiconductor devices required to dissipate more than 250 mW or any case temperature that is 10 degrees C above ambient shall be mounted with spacers or transpads to prevent direct contact with the PCB. When completed all residual flux shall be removed from PCB.
 - 1.6.1.4.2 The resistance between any 2 isolated, independent conductor paths shall be at least 100 megohms when a 500 VDC potential is applied.
 - 1.6.1.4.3 All PCB's shall be coated with a moisture resistant coating.
 - 1.6.1.4.4 Where less than 0.25 inch lateral separation is provided between the PCB (or the components of a PCB) and any metal surface, a 0.03125 (-0.0 to +0.0156) inch thick Mylar (polyester) plastic cover shall be provided on the metal to protect the PCB.
- 1.6.1.5 Each PCB connector edge shall be chamfered at 30 degrees from board side planes. The key slots shall also be chamfered so that the connector keys are not extracted upon removal of board or jammed upon insertion. The key slots shall be 0.045 (± 0.005) inch for 0.1 inch spacing and 0.055 (± 0.005) inch for 0.156 inch spacing.
- 1.6.1.6 **PCB Circuit Reference Markings - PCBs shall have circuit reference symbols clearly and legibly marked by silkscreen, circuit printing or similar permanent marking system on the circuit side, as nearby as practicable to the component referenced. PCB circuit reference symbols shall be identical to those depicted on the pictorial diagram within the manual which shows the physical locations and identification of each component.**

This component marking requirement shall apply to all PCBs except those within Model 200 Switchpacks and Model 204 Flasher Units.

1.6.2 Soldering

1.6.2.1 Hand soldering shall comply with Military Specification: MIL-P-55110.

1.6.2.2 Automatic flow soldering shall conform to the following conditions:

1.6.2.2.1 Constant speed conveyor system.

1.6.2.2.2 Conveyor speed shall be the optimum to minimize solder peaks or points which form at component terminals.

1.6.2.2.3 Temperature shall be controlled to within ± 8 degrees C of the optimum temperature.

1.6.2.2.4 The soldering process shall result in the complete coverage of all solder runs, joints and terminals with solder except that which is covered by an electroplating process.

1.6.2.2.5 Whenever clinching is not used, a method of holding the components in the proper position for the flow process shall be provided.

1.6.2.2.6 If exposure to the temperature bath is of such a time-temperature duration, as to come within 80% of any component's maximum specified time-temperature exposure, that component shall be hand soldered to the PCB after the flow process has been completed.

1.6.3 Printed circuit board mounting. All printed circuit boards shall be mounted vertically (the copper clad surfaces shall be oriented vertically).

1.6.4 Definitions - Definitions for the purpose of this section on PCB's shall be taken from MIL-STD-429 and any current addendum.

1.7 SECTION 7 - QUALITY CONTROL

The following measures shall be taken by the Contractor during the production process to ensure a high standard of quality.

1.7.1 Components - All components shall be lot sampled to assure a consistent high conformance standard to the design specification of the unit.

1.7.2 Subassembly or module

1.7.2.1 Visual inspection shall be performed on all modules, printed circuits and subassemblies to determine any physical defects such as cracking, scaling, poor fastening, incorrect component values and etc.

1.7.2.2 Complete electrical testing shall be performed on each module, printed circuit board or subassembly to determine its compliance to the manufacturer's design function.

1.7.2.3 Housing, chassis, and connection terminals shall be inspected for mechanical sturdiness, and harnessing to sockets shall be electrically tested for proper wiring sequence.

1.7.3 Units

1.7.3.1 The completely assembled unit shall be subjected to a full environmental cycling and timing test.

1.7.3.2 The unit shall be visually and physically inspected to assure proper placement, mounting and compatibility of subassemblies.

1.7.4 Pre-delivery Repair

1.7.4.1 The procedures listed below shall be followed in repair of equipment before shipment.

1.7.4.1.1 Any defects or deficiencies found by the inspection system involving mechanical structure or wiring shall be returned through the manufacturing process or special repair process for correction.

1.7.4.1.2 Defects in PCB's or electronic circuit components shall be specially treated as follows:

1.7.4.1.2.1 A PCB may be flow soldered a second time if copper runs and joints are not satisfactorily coated on the first run.

1.7.4.1.2.2 Under no circumstances shall a PCB be flow soldered more than twice.

1.7.4.1.2.3 Hand soldering may be used for printed circuit repair.

1.8 SECTION 8 - ELECTRICAL, ENVIRONMENTAL AND TESTING REQUIREMENTS

1.8.1 General

1.8.1.1 The General procedures and equipment used in the evaluation of the controller unit, cabinet and auxiliary equipment are a minimum guide and should not limit the testing and inspection to ensure compliance of the equipment with these specifications.

1.8.1.2 These test procedures shall be followed by the Contractor who shall certify that he has conducted inspection and testing in accordance with these specifications.

1.8.2. Inspection - A visual and physical inspection shall include mechanical, dimensional and assembly conformance of all parts of these specifications which can be checked visually or manually with simple measuring devices.

1.8.3 Environmental - All components shall properly operate within the following limits:

1.8.3.1 Ambient Temperature: -37 degrees C to 74 degrees C

1.8.3.2 Humidity: 5 to 95 percent

1.8.3.3 The relative humidity and ambient temperature values in the following table shall not be exceeded.

AMBIENT TEMPERATURE VERSUS RELATIVE
HUMIDITY AT BAROMETRIC PRESSURES (29.92 in. Hg.)

Ambient Temperature/ Dry Bulb (in deg C)	Relative Humidity (in percent)	Ambient Temperature/ Wet Bulb (in deg C)
-37 to 1.1	10	-17.2 to 42.7
1.1 to 46.0	95	42.7
48.8	70	42.7
54.4	50	42.7
60.0	38	42.7

65.4	28	42.7
71.2	21	42.7
74	18	42.7

1.8.3.4 Shock Test - per Military Specification: MIL-STD-810D Method 516.1.

1.8.3.5 Vibration - per Military Specification: MIL-STD-810D Method 514.1, equipment class G (Common Carrier).

1.8.3.6 Cabinets shall comply with the requirements of UL Bulletin of Research No. 23, "Rain Tests of Electrical Equipment".

1.8.3.7 All equipment shall continue normal operation when subjected to the following:

1.8.3.7.1 Low Temperature Test - With the item functioning at a line voltage of 90 VAC in its intended operation, the ambient temperature shall be lowered from 20 degrees C to -37 degrees C at a rate of not more than 18 degrees C per hour. The item shall be cycled at -37 degrees C for a minimum of 5 hours and then returned to 20 degrees C at the same rate. The test shall be repeated with the line voltage at 135 VAC.

1.8.3.7.2 High Temperature Test - With the item functioning at a line voltage of 90 VAC in its intended operation, the ambient temperature shall be raised from 20 degrees C to 70 degrees C at a rate of not more than 18 degrees C per hour. The item shall be cycled at 70 degrees C for a minimum of 5 hours and then returned to 20 degrees C at the same rate. The test shall be repeated with the line voltage at 135 VAC.

1.8.4 Electrical - All components shall operate properly within the following limits:

1.8.4.1 Applied Line Voltage: 90 to 135 VAC

1.8.4.2. Frequency: 60 (± 3.0) Hertz

1.8.4.3 All circuits unless otherwise noted, shall commence operation at or below 90 VAC as the applied voltage is raised from 50 VAC to 90 VAC at a rate of 2 (± 0.5) volts per second.

1.8.4.4 All equipment, when housed within its associated cabinet, shall be unaffected by transient voltages normally experienced on commercial power lines. Equipment purchased separately from cabinet will be tested for compliance with the equipment housed within a City of Winnipeg Accepted Model 332 Cabinet and the cabinet connected to the commercial power lines.

1.8.4.4.1 The power line surge protection, (including the cabinet's and that internal to the equipment) shall enable the equipment being tested to withstand (nondestructive) and operate normally following the discharge of a 25 microfarad capacitor, charged to plus and minus 2,000 volts, applied directly across the AC line (applied at Cabinet Service Terminal Block) at a rate of once every 10 seconds for a maximum of 50 occurrences per test. The unit under test will be operated at 20 degrees (± 5 degrees) C and at 120 (± 12) VAC.

1.8.4.4.2 The Model 400 MODEM will be housed in a City Accepted Model 170E Controller Unit which in turn is housed in the cabinet during the test described above.

1.8.4.5 All equipment shall be unaffected by transient voltages normally experienced on commercial power lines. Equipment purchased separately from the cabinet will be tested

for compliance as follows:

- 1.8.4.5.1 Power from commercial power lines applied at Cabinet Service Terminal Block.
 - 1.8.4.5.2 Equipment properly housed and connected within a City of Winnipeg Accepted Model 332 Cabinet.
 - 1.8.4.5.3 The Cabinet Power Surge Protectors deactivated or removed.
 - 1.8.4.5.4 The equipment shall withstand (nondestructive) and operate normally when one discharge pulse of plus or minus 300 volts is synchronously added to the AC power at the Cabinet Service Terminal Block and moved uniformly over the full wave across 360 degrees or stay at any point of Line Cycle once every second. Peak noise power shall be 5 kilowatts with a pulse rise time of 500 ns. The unit under test will be operated at 20 (+/-5) degrees C and at 120 (\pm 12) VAC.
 - 1.8.4.5.4.1 The Model 400 MODEM shall comply to the above conditions when housed in a City Accepted Model 170E Controller Unit and with DAT Program operating, and tested under the above conditions.
 - 1.8.4.5.4.2 Within the circuit of any device, module or PCB, electrical isolation shall be provided between DC logic ground, equipment ground and the AC grounded conductor. The DC logic ground and equipment ground shall be electrically isolated from the AC grounded conductor and from each other by 500 megohms, minimum, when tested at the input terminals with 500 VDC.
 - 1.8.4.6 All equipment shall be capable of normal operation following opening and closing of contacts in series with the applied voltage to the cabinet at a rate of 30 openings and closings per minute for a period of 2 minutes in duration.
 - 1.8.4.7 All equipment shall resume normal operation following a period of at least 5 hours at -37 degrees C and less than 10% humidity, when 90 VAC is applied to the input terminals of the cabinet.
- 1.8.5 Contractor's Testing Certification
- 1.8.5.1 The Contractor shall supply with each shipment a full test report of the quality control and final test conducted on each item. The test report shall indicate the name of the tester and shall be signed by a responsible manager.
 - 1.8.5.2 The Contractor shall submit his quality control procedure and format of test reports to the Engineer for approval within 15 working days following the approval of the contract.
 - 1.8.5.3 The quality control procedure shall include the following:
 - 1.8.5.3.1 Acceptance testing of all supplied components.
 - 1.8.5.3.2 Physical and functional testing of all modules.
 - 1.8.5.3.3 A minimum 100-hour burn-in of all modules.
 - 1.8.5.3.4 Physical and functional testing of all items.
 - 1.8.5.3.5 A minimum 24 hour operation of all controller units and cabinets.