STATE OF TENNESSEE

March 1, 2006

(Rev. 01-03-07)
(Rev. 07-14-07)
(Rev. 04-23-08)

SPECIAL PROVISION

REGARDING

TENNESSEE DEPARTMENT OF TRANSPORTATION

2008 MINIMUM WAGE SCALES FOR FEDERAL-AID CONSTRUCTION

& 2008 MINIMUM WAGE SCALES FOR STATE FUNDED CONSTRUCTION

This Contract contains "Tennessee Department of Transportation 2008 Minimum Wage Scales for State Funded Construction", Tennessee Department of Labor Decision No. T-32124, dated December 14, 2007, and Tennessee Department of Transportation 2008 Minimum Wage Scales for Federal-Aid Highway Construction, U. S. Department of Labor Decision Nos. TN20080010 (dated February 8, 2008) and TN20080017 (dated February 8, 2008).

The Contractor is required to pay the greater of the two (2) rates for each classification.

Note: Minimum Wage Scales for Federal-Aid Heavy Construction are on file with the Department, and will be included in all applicable Contract Proposals.

(Rev. 4-23-08)

STATE OF TENNESSEE

TENNESSEE DEPARTMENT OF TRANSPORTATION

MINIMUM WAGE SCALES FOR FEDERAL AID HIGHWAY CONSTRUCTION

Date: February 8, 2008
General Decision Number: **TN20080010**

Superseded General Decision Number: TN20070017

Construction Types: Highway

Counties: Anderson, Blount, Carter, Cheatham, Davidson, Dickson, Grainger, Hamilton, Hawkins, Jefferson, Knox, Madison, Marion, Montgomery, Robertson, Rutherford, Sevier, Shelby, Sullivan, Sumner, Tipton, Unicoi, Union, Washington, Williamson and Wilson Counties in Tennessee.

Date: February 8, 2008
General Decision Number: **TN20080017**

Superseded General Decision Number: TN20070057

Construction Types: Highway

Counties: Bedford, Benton, Bledsoe, Bradley, Campbell, Cannon, Carroll, Chester, Claiborne, Clay, Cocke, Coffee, Crockett, Cumberland, De Kalb, Decatur, Dyer, Fayette, Fentress, Franklin, Gibson, Giles, Greene, Grundy, Hamblen, Hancock, Hardeman, Hardin, Haywood, Henderson, Henry, Hickman, Houston, Humphreys, Jackson, Johnson, Lake, Lauderdale, Lawrence, Lewis, Lincoln, Loudon, Macon, Marshall, Maury, McMinn, McNairy, Meigs, Monroe, Moore, Morgan, Obion, Overton, Perry, Pickett, Polk, Putnam, Rhea, Roane, Scott, Smith, Stewart, Trousdale, Van Buren, Warren, Wayne, Weakley and White Counties in Tennessee.

CLASSIFICATION	For Counties in Decision TN20080010 Rates	For Counties in Decision TN20080017 Rates
Bricklayer	$11.49	$8.84
Carpenter	$10.41	$8.58
Concrete Finisher	$10.01	$8.35
Drill Operator (Caisson)	$12.65	$13.98
Electrician	$16.60	$11.89
Ironworkers		
-Reinforcing	$9.63	$8.41
-Structural	$12.32	$10.00
Laborers		
- Group 1	$7.62	$5.93
- Group 2	$8.89	$7.54
Mechanic		
- Heavy Duty	$10.33	$9.00
- Light Duty	$12.36	$8.91
Painter & Sandblaster	$12.94	$9.52
Powder Person (Blaster)	$10.14	$8.03
Power Equipment Operators		
- Group 1	$11.46	$9.17
- Group 2	$9.97	$8.50
- Group 3	$10.07	$8.31
- Group 4	$9.33	$7.79
- Group 5	$10.30	$10.18
- Group 6	$8.00	$6.56
Truck drivers		
- 2 or 3 axles	$8.43	$7.37
- 4 or 5 axles heavy duty	$8.75	$7.55

WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

LABORER CLASSIFICATIONS

GROUP 1 - Unskilled Laborer; Flaggers; Traffic Control Pickup Driver

GROUP 2 - Skilled Laborers: Air tool operator, Asphalt Raker, Chain saw operator, Concrete Mixer Operator (Less than 1 yard), Concrete Rubber/Edger, Fence Erector, Form Setter (Steel Road), Guard Rail Erector, Mechanic's Tender (Tire Changer or Oiler), Mortar Mixer, Nozzleman or Gun Operator (Gunite), Pipelayer, Sign Erector.

POWER EQUIPMENT OPERATOR CLASSIFICATIONS

GROUP 1: Backhoe/Hydraulic Excavator (3/4 yard & over) Crane, End Loader (3 yards & over), Motor Patrol (Finish), Pile Driver, Dragline.

GROUP 2: Backhoe/Hydraulic Excavator (Less than 3/4 yard), Bull dozer or Push dozer, End Loader (Less than 3 yards), Motor Patrol operator (Rough), Tractor (Crawler/Utility), Scraper, Shovel, Trenching Machine.

GROUP 3: Asphalt Paver, Concrete Finishing Machine, Concrete Paver, Scale, Spreader (Self-Propelled), Concrete Grinder, Asphalt Milling Machine, Boring Machine Operator (Horizontal).

GROUP 4: Bobcat, Central Mixing Plant, Concrete Pump, Concrete Saw, Curb machine (Automatic or Manual), Dozer or Loader Operator (Stockpile), Drill Operator (piling), Mulcher or Seeder, Rock Drill (truck mounted), Roller (asphalt), Roller (compaction self-propelled), Soil Stabilization Machine, Tractor (boom & hoist), Bituminous Distributor Machine, Ditch Paving Machine, Pump, Track Drill, Striping Machine Operator.

GROUP 5: Sweeping Machine Operator

GROUP 6: Farm Tractor Operator.

STATE OF TENNESSEE

TENNESSEE DEPARTMENT OF TRANSPORTATION

2008 MINIMUM WAGE SCALES FOR STATE FUNDED CONSTRUCTION

December 14, 2007

Tenn. DOL Decision No. T-32124

CLASSIFICATION (ENGLISH)	CLASSIFICATION (SPANISH)	Basic Hourly Rates	Craft No.
Bricklayer	Ladrillero	16.32	01
Carpenter / Leadsperson	Carpintero o Lider	15.40	02
Class "A" Operators	Operador Clase A	16.54	03
Class "B" Operators	Operador Clase B	14.75	04
Class "C" Operators	Operador Clase C	14.96	05
Class "D" Operators	Operador Clase D	13.70	06
Concrete Finisher	Terminador de Cemento	13.27	07
Drill Operator (Caisson)	Operador de Perfordora	17.39	08
Electrician	Electricista	21.39	09
Farm Tractor Operator (Power Broom)	Operador de Tractor de Rancho	12.17	10
Ironworkers (Reinforcing)	Herrero	17.06	11
Ironworkers (Structural)	Herrero de Estructura	16.84	12
Mechanic (Class I) Heavy Duty	Mecanico Clase 1	18.04	13
Mechanic (Class II) Light Duty	Mecanico Clase 2	15.79	14
Painter / Sandblaster	Pintor o Lajador	21.15	15
Powder Person / Blaster	Proveedor de Explosivos	17.47	16
Skilled Laborer	Obrero Diestro	12.70	17
Survey Instrument Operator	Operador de Agrimensor	14.39	18
Sweeping Machine (Vacuum) Operator	Operador de Barredora	13.15	19
Truck Driver (2 axles)	Camionero (2 ejes)	13.52	20
Truck Driver (3/4 axles)	Camionero (3 o 4 ejes)	12.78	21
Truck Driver (5 or more axles)	Camionero (5 o más ejes)	14.70	22
Laborer /Unskilled , Flagger, Traffic Control, Pickup Driver	Obrero no Diestro	10.94	23
Worksite Traffic Coordinator	Coordinar de Trafico en el Lugar de Trabajo	15.23	24

CLASSIFICATION	CRAFT NO.	BASIC HOURLY RATES
SKILLED LABORER:	17	12.70

Air Tool Operator, Asphalt Raker, Chain Saw Operator, Concrete Mixer Operator (less than 1 yard), Concrete Rubber/Edger, Fence Erector, Form Setter (Steel Road), Guardrail Erector, Mechanic's Helper (Tire Changer or Oiler), Mortar Mixer, Nozzelman or Gun Operator (Gunite), *Pipelayer, Sign Erector

CLASS "A" OPERATORS:	03	16.54

Backhoe/Hydraulic Excavator (3/4 yard and over), Crane, End Loader (3 yards and over), Motor Patrol (Finish), Pile Driver, Dragline

CLASS "B" OPERATORS:	04	14.75

Backhoe/Hydraulic Excavator (less than 3/4 yard), Bull Dozer or Push Dozer, End Loader (less than 3 yards), Motor Patrol (Rough), Tractor (Crawler/Utility), Scraper, Shovel, Trenching Machine

CLASS "C" OPERATORS:	05	14.96

Asphalt Paver, Concrete Finishing Machine, Concrete Paver, Scale, Spreader (Self-Propelled), Concrete Grinder, Asphalt Milling Machine, Boring Machine Operator (Horizontal)

CLASS "D" OPERATORS:	06	13.70

Bobcat, Central Mixing Plant, Concrete Pump, Concrete Saw, Curb Machine (Automatic or Manual), Dozer or Loader (Stockpile), Drill (Piling), Mulcher or Seeder, Rock Drill (Truck Mounted), Roller (Asphalt), Roller (Compaction Self-Propelled), Soil Stabilization Machine, Tractor (Boom & Hoist), Bituminous Distributor Machine, Pump, Track Drill, Striping Machine Operator, Ditch Paving Machine

*Skilled Laborer - Pipelayer Classification

For any work where prevailing wage rates apply which is located five feet or more outside the actual building if building construction is involved:

AND

(a) which consists of the building, rebuilding, locating, relocating or repairing any street, highway, bridges, water lines, sewer lines, gas lines, force mains or other related utilities

OR

(b) which involves the construction or upgrading of industrial parks or sites and is located outside the five foot limitation.

The classification of pipelayer shall be applicable and the description of work under this classification shall be as follows:

> **Lays, connects, inspects and tests water lines, force mains, gas lines, sanitary or storm sewers and drains, underground telephone and electric ducts or other utilities manufactured from clay, concrete, steel, plastic, cast iron pipe or other similar materials.**
>
> **May smooth bottom of trench to proper elevation by scooping with a shovel; receives pipe lowered from top of trench; inserts spigot end of pipe into bell end of last laid pipe; adjusts pipe to line and grades, caulks and seals joint with cement or other sealing compound; may connect threaded or flanged joint pipe; may assemble and place corrugated metal or plastic pipe and performs other related duties.**

Additional Information :

Wage Rates : http://www.tennessee.gov/labor-wfd/prevail.html

Poster Page : http://www.state.tn.us/labor-wfd/poster.htm

> **Note: Adobe Acrobat Reader is required in order to download & print. If you do not have this software a link is provided at the bottom of the Poster Page for a free download.**

Tenn.Dept. of Labor & Workforce Development (Labor Standards Division) : (615) 741-2858.

APPRENTICESHIP REGULATIONS:

Under T.C.A., §12-449, the Prevailing Wage Commission has promulgated Rule 0800-3-2-.04 which provides that: "Apprentices shall mean those persons registered individually under a bona fide apprenticeship program registered with the Bureau of Apprentiship and Training in the United States Department of Labor. The state agency contracting officer shall require the contractor or sub-contractor using the apprentice to submit evidence of his indenture and/or apprenticeship registration when the apprentice's name first appears on a submitting payroll."

AUTHORITY: T.C.A., §12-449. Administrative History: Original Rule filed June 4, 1976. Effective: July 14, 1976.

§18.42 Retention and access requirements for records.

a. *Applicability.*
   1. This section applies to all financial and programmatic records, supporting documents, statistical records, and other records of grantees or subgrantees which are:
      i. Required to be maintained by the terms of this part, program regulations or the grant agreement, or
      ii. Otherwise reasonably considered as pertinent to program regulations or the grant agreement.
   2. This section does not apply to records maintained by contractors or subcontractors. For a requirement to place a provision concerning records in certain kinds of contracts, see §18.36(i)(10).

b. *Length of retention period.*
   1. Except as otherwise provided, records must be retained for three years from the starting date specified in paragraph (c) of this section.
   2. If any litigation, claim, negotiation, audit or other action involving the records has been started before the expiration of the 3-year period, the records must be retained until completion of the action and resolution of all issues which arise from it, or until the end of the regular 3-year period, whichever is later.
   3. To avoid duplicate recordkeeping, awarding agencies may make special arrangements with grantees and subgrantees to retain any records which are continuously needed for joint use. The awarding agency will request transfer of records to its custody when it determines that the records possess long-term retention value. When the records are transferred to or maintained by the Federal agency, the 3-year retention requirement is not applicable to the grantee or subgrantee.

c. *Starting date of retention period* --
   1. *General.* When grant support is continued or renewed at annual or other intervals, the retention period for the records of each funding period starts on the day the grantee or subgrantee submits to the awarding agency its single or last expenditure report for that period. However, if grant support is continued or renewed quarterly, the retention period for each year's records starts on the day the grantee submits its expenditure report for the last quarter of the Federal fiscal year. In all other cases, the retention period starts on the day the grantee submits its final expenditure report. If an expenditure report has been waived, the retention period starts on the day the report would have been due.
   2. *Real property and equipment records.* The retention period for real property and equipment records starts from the date of the disposition or replacement or transfer at the direction of the awarding agency.
   3. *Records for income transactions after grant or subgrant support.* In some cases grantees must report income after the period of grant support. Where there is such a requirement, the retention period for the records pertaining to the earning of the income starts from the end of the grantee's fiscal year in which the income is earned.
   4. *Indirect cost rate proposals, cost allocations plans, etc.* This paragraph applies to the following types of documents, and their supporting records: indirect cost rate computations or proposals, cost allocation plans, and any similar accounting computations of the rate at which a particular group of costs is chargeable (such as computer usage chargeback rates or composite fringe benefit rates).
      i. *If submitted for negotiation.* If the proposal, plan, or other computation is required to be submitted to the Federal Government (or to the grantee) to form the basis for negotiation of the rate, then the 3-year retention period for its supporting records starts from the date of such submission.
      ii. *If not submitted for negotiation.* If the proposal, plan, or other computation is not required to be submitted to the Federal Government (or to the grantee) for negotiation purposes, then the 3-year retention period for the proposal plan, or computation and its supporting records starts from theend of the fiscal year (or other accounting period) covered by the proposal, plan, or other computation.

d. *Substitution of microfilm.* Copies made by microfilming, photocopying, or similar methods may be substituted for the original records.

e. *Access to records* --
   1. *Records of grantees and subgrantees.* The awarding agency and the Comptroller General of the United States, or any of their authorized representatives, shall have the right of access to any pertinent books, documents, papers, or other records of grantees

and subgrantees which are pertinent to the grant, in order to make audits, examinations, excerpts, and transcripts.

2. *Expiration of right of access.* The right of access in this section must not be limited to the required retention period but shall last as long as the records are retained.

f. *Restrictions on public access.* The Federal Freedom of Information Act (5 U.S.C. 552) does not apply to records unless required by Federal, State, or local law, grantees and subgrantees are not required to permit public access to their records.

§18.36 Procurement.

i. *Contract provisions.* A grantee's and subgrantee's contracts must contain provisions in paragraph (i) of this section. Federal agencies are permitted to require changes, remedies, changed conditions, access and records retention, suspension of work, and other clauses approved by the Office of Federal Procurement Policy.

1. Administrative, contractual, or legal remedies in instances where contractors violate or breach contract terms, and provide for such sanctions and penalties as may be appropriate. (Contracts more than the simplified acquisition threshold)
2. Termination for cause and for convenience by the grantee or subgrantee including the manner by which it will be effected and the basis for settlement. (All contracts in excess of $10,000)
3. Compliance with Executive Order 11246 of September 24, 1965, entitled "Equal Employment Opportunity," as amended by Executive Order 11375 of October 13, 1967, and as supplemented in Department of Labor regulations (41 CFR chapter 60). (All construction contracts awarded in excess of $10,000 by grantees and their contractors or subgrantees)
4. Compliance with the Copeland "Anti-Kickback" Act (18 U.S.C. 874) as supplemented in Department of Labor regulations (29 CFR part 3). (All contracts and subgrants for construction or repair)
5. Compliance with the Davis-Bacon Act (40 U.S.C. 276a to 276a-7) as supplemented by Department of Labor regulations (29 CFR part 5). (Construction contracts in excess of $2000 awarded by grantees and subgrantees when required by Federal grant program legislation)
6. Compliance with Sections 103 and 107 of the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-330) as supplemented by Department of Labor regulations (29 CFR part 5). (Construction contracts awarded by grantees and subgrantees in excess of $2000, and in excess of $2500 for other contracts which involve the employment of mechanics or laborers)
7. Notice of awarding agency requirements and regulations pertaining to reporting.
8. Notice of awarding agency requirements and regulations pertaining to patent rights with respect to any discovery or invention which arises or is developed in the course of or under such contract.
9. Awarding agency requirements and regulations pertaining to copyrights and rights in data.
10. Access by the grantee, the subgrantee, the Federal grantor agency, the Comptroller General of the United States, or any of their duly authorized representatives to any books, documents, papers, and records of the contractor which are directly pertinent to that specific contract for the purpose of making audit, examination, excerpts, and transcriptions.
11. Retention of all required records for three years after grantees or subgrantees make final payments and all other pending matters are closed.
12. Compliance with all applicable standards, orders, or requirements issued under section 306 of the Clean Air Act (42 U.S.C. 1857(h)), section 508 of the Clean Water Act (33 U.S.C. 1368), Executive Order 11738, and Environmental Protection Agency regulations (40 CFR part 15). (Contracts, subcontracts, and subgrants of amounts in excess of $100,000)
13. Mandatory standards and policies relating to energy efficiency which are contained in the state energy conservation plan issued in compliance with the Energy Policy and Conservation Act (Pub. L. 94-163, 89 Stat. 871).

§18.26 Non-Federal audits.

a. *Basic rule.* Grantees and subgrantees are responsible for obtaining audits in accordance with the Single Audit Act Amendments of 1996 (31 U.S.C. 7501-7507) and revised OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations." The audits shall be made by an independent auditor in accordance with generally accepted government auditing standards covering financial audits.

b. *Subgrantees.* State or local governments, as those terms are defined for purposes of the Single Audit Act Amendments of 1996, that provide Federal awards to a subgrantee, which expends $300,000 or more (or other amount as specified by OMB) in Federal awards in a fiscal year, shall:

   1. Determine whether State or local subgrantees have met the audit requirements of the Act and whether subgrantees covered by OMB Circular A-110, "Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Non-Profit Organizations," have met the audit requirements of the Act. Commercial contractors (private for-profit and private and governmental organizations) providing goods and services to State and local governments are not required to have a single audit performed. State and local governments should use their own procedures to ensure that the contractor has complied with laws and regulations affecting the expenditure of Federal funds;
   2. Determine whether the subgrantee spent Federal assistance funds provided in accordance with applicable laws and regulations. This may be accomplished by reviewing an audit of the subgrantee made in accordance with the Act, Circular A-110, or through other means (e.g., program reviews) if the subgrantee has not had such an audit;
   3. Ensure that appropriate corrective action is taken within six months after receipt of the audit report in instance of noncompliance with Federal laws and regulations;
   4. Consider whether subgrantee audits necessitate adjustment of the grantee's own records; and
   5. Require each subgrantee to permit independent auditors to have access to the records and financial statements.

c. *Auditor selection.* In arranging for audit services, §18.36 shall be followed.

Federal Highway Administration
Department of Transportation
Required Contract Provisions

PART 635-CONSTRUCTION AND MAINTENANCE

§ 635.108 Health and safety.

Contracts for projects shall include provisions designed:

(a) To insure full compliance with all applicable Federal, State, and local laws governing safety, health and sanitation; and

(b) To require that the contractor shall provide all safeguards, safety devices, and protective equipment and shall take any other actions reasonably necessary to protect the life and health of persons working at the site of the project and the safety of the public and to protect property in connection with the performance of the work covered by the contract.

§635.109 Standardized changed condition clauses.

(a) Except as provided in paragraph (b) of this section, the following changed conditions contract clauses shall be made part of, and incorporated in, each highway construction project approved under 23 U.S.C. 106:

(1) Differing site conditions.

(i) During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the site is disturbed and before the affected work is performed.

(ii) Upon written notification, the engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding anticipated profits, will be made and the contract modified in writing accordingly. The engineer will notify the contractor of the determination whether or not an adjustment of the contract is warranted.

(iii) No contract adjustment which results in a benefit to the contractor will be allowed unless the contractor has provided the required written notice.

(iv) No contract adjustment will be allowed under this clause for any effects caused on unchanged work. (This provision may be omitted by the STD's at their option.)

(2) Suspensions of work ordered by the engineer.

(i) If the performance of all or any portion of the work is suspended or delayed by the engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the contractor believes that additional compensation and/ or contract time is due as a result of such suspension or delay, the contractor shall submit to the engineer in writing a request for adjustment within 7 calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

(ii) Upon receipt, the engineer will evaluate the contractor's request. If the engineer agrees that the cost and/or time required for the performance of the contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the contractor, its suppliers, or subcontractors at any approved tier, and not caused by weather, the engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. The contractor will be notified of the engineer's determination whether or not an adjustment of the contract is warranted.

(iii) No contract adjustment will be allowed unless the contractor has submitted the request for adjustment within the time prescribed.

(iv) No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided or excluded under any other term or condition of this contract.

(3) Significant changes in the character of work.

(i) The engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project. Such changes in quantities and alterations shall not invalidate the contract nor release the surety, and the contractor agrees to perform the work as altered.

(ii) If the alterations or changes in quantities significantly change the character of the work under the contract, whether such alterations or changes are in themselves significant changes to the character of the work or by affecting other work cause such other work to become significantly different in character, an adjustment, excluding anticipated profit, will be made to the contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the contractor in such amount as the engineer may determine to be fair and equitable.

(iii) If the alterations or changes in quantities do not significantly change the character of the work to be performed under the contract, the altered work will be paid for as provided elsewhere in the contract.

(iv) The term "significant change" shall be construed to apply only to the following circumstances:

(A) When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction; or

(B) When a major item of work, as defined elsewhere in the contract, is increased in excess of 125 percent or decreased below 75 percent of the original contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125 percent of original contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed.

(b) The provisions of this section shall be governed by the following:

(1) Where State statute does not permit one or more of the contract clauses included in paragraph (2) of this section, the State statute shall prevail and such clause or clauses need not be made applicable to Federal-aid highway contracts.

(2) Where the State transportation department has developed and implemented one or more of the contract clauses included in paragraph (a) of this section, such clause or clauses, as developed by the State transportation department may be included in Federal-aid highway contracts in lieu of the

corresponding clause or clauses in paragraph (a) of this section. The State's action must be pursuant to a specific State statute requiring differing contract conditions clauses. Such State developed clause or clauses, however, must be in conformance with 23 U.S.C., 23 CFR and other applicable Federal statutes and regulations as appropriate and shall be subject to the Division Administrator's approval as part of the PS&E.

(c) In the case of a design-build project, STDs are strongly encouraged to use "suspensions of work ordered by the engineer" clauses, and may consider "differing site condition" clauses and "significant changes in the character of work" clauses which are appropriate for the risk and responsibilities that are shared with the design-builder.

§635.112 Advertising for bids and proposals.

f) The STD shall include a noncollusion provision substantially as follows in the bidding documents:

Each bidder shall file a statement executed by, or on behalf of the person, firm, association, or corporation submitting the bid certifying that such person, firm, association, or corporation has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action, in restraint of free competitive bidding in connection with the submitted bid. Failure to submit the executed statement as part of the bidding documents will make the bid nonresponsive and not eligible for award consideration.

§635.116 Subcontracting and contractor responsibilities.

(a) Contracts for projects shall specify the minimum percentage of work that a contractor must perform with its own organization. This percentage shall be not less than 30 percent of the total original contract price excluding any identified specialty items. Specialty items may be performed by subcontract and the amount of any such specialty items so performed may be deducted from the total original contract before computing the amount of work required to be performed by the contractor's own organization. The contract amount upon which the above requirement is computed includes the cost of materials and manufactured products which are to be purchased or produced by the contractor under the contract provisions.

(b) The STD shall not permit any of the contract work to be performed under a subcontract, unless such arrangement has been authorized by the STD in writing. Prior to authorizing a subcontract, the STD shall assure that each subcontract is evidenced in writing and that it contains all pertinent provisions and requirements of the prime contract. The Division Administrator may permit the STD to satisfy the subcontract assurance requirements by concurrence in a STD process which requires the contractor to certify that each subcontract arrangement will be in the form of a written agreement containing all the requirements and pertinent provisions of the prime contract. Prior to the Division Administrator's concurrence, the STD must demonstrate that it has an acceptable plan for monitoring such certifications.

(c) To assure that all work (including subcontract work) is performed in accordance with the contract requirements, the contractor shall be required to furnish:

(1) A competent superintendent or supervisor who is employed by the firm, has full authority to direct performance of the work in accordance with the contract requirements, and is in charge of all construction operations (regardless of who performs the work), and;

(2) Such other of its own organizational resources (supervision, management, and engineering services) as the STD contracting officer determines are necessary to assure the performance of the contract.

(d) In the case of a design-build project, the following requirements apply:

(1) The provisions of paragraph (a) of this section are not applicable to design-build contracts;

(2) At their discretion, the STDs may establish a minimum percentage of work that must be done by the design-builder. For the purpose of this section, the term design-builder may include any firms that are equity participants in the design-builder, their sister and parent companies, and their wholly owned subsidiaries;

(3) No procedure, requirement or preference shall be imposed which prescribes minimum subcontracting requirements or goals (other than those necessary to meet the Disadvantaged Business Enterprise program requirements of 49 CFR part 26).

§ 635.117 Labor and employment.

(a) No construction work shall be performed by convict labor at the work site or within the limits of any Federal-aid highway construction project from the time of award of the contract or the start of work on force account until final acceptance of the work by the STD unless it is labor performed by convicts who are on parole, supervised release, or probation.

(b) No procedures or requirement shall be imposed by any State which will operate to discriminate against the employment of labor from any other State, possession or territory of the United States, in the construction of a Federal-aid project.

(c) The selection of labor to be employed by the contractor on any Federal-aid project shall be by the contractor without regard to race, color, religion, sex, national origin, age, or handicap and in accordance with 23 CFR part 230, 41 CFR part 60 and Exec. Order No. 11246 (Sept. 24, 1965), 3 CFR 339 (1964-1965), as amended.

(d) Pursuant to 23 U.S.C. 140(d), it is permissible for STD's to implement procedures or requirements which will extend preferential employment to Indians living on or near a reservation on eligible projects as defined in paragraph (e) of this section. Indian preference shall be applied without regard to tribal affiliation or place of enrollment. In no instance should a contractor be compelled to layoff or terminate a permanent core-crew employee to meet a preference goal.

(e) Projects eligible for Indian employment preference consideration are projects located on roads within or providing access to an Indian reservation or other Indian lands as defined under the term "Indian Reservation Roads" in 23 U.S.C. 101 and regulations issued there under. The terminus of a road "providing access to" is that point at which it intersects with a road functionally classified as a collector or higher classification (outside the reservation boundary) in both urban and rural areas. In the case of an Interstate highway, the terminus is the first interchange outside the reservation.

(f) The advertisement or call for bids on any contract for the construction of a project located on the Federal-aid system either shall include the minimum wage rates determined by the Secretary of Labor to be prevailing on the same type of work on similar construction in the immediate locality or shall provide that such rates are set out in the bidding documents and shall further specify that such rates are a part of the contract covering the project.

§ 635.125 Termination of contract.

(a) All contracts exceeding $10,000 shall contain suitable provisions for termination by the State, including the manner by which the termination will be effected and the basis for settlement. In addition, such contracts shall describe conditions under which the contract may be terminated for default as well as conditions where the contract may be terminated because of circumstances beyond the control of the contractor.

(b) The STD prior to termination of a Federal-aid contract shall consult with and receive the concurrence of the Division Administrator. The extent of Federal-aid participation in contract termination costs, including final settlement, will depend upon the merits of the individual case. However, under no circumstances shall Federal funds participate in anticipated profit on work not performed.

(c) Except as provided for in paragraph (e) of this section, normal Federal-aid plans, specifications, and estimates, advertising, and award procedures are to be followed when a STD awards the contract for completion of a terminated Federal-aid contract.

(d) When a STD awards the contract for completion of a Federal-aid contract previously terminated for default, the construction amount eligible for Federal participation on the project should not exceed whichever amount is the lesser, either:

(1) The amount representing the payments made under the original contract plus payments made under the new contract; or

(2) The amount representing what the cost would have been if the construction had been completed as contemplated by the plans and specifications under the original contract.

(e) If the surety awards a contract for completion of a defaulted Federal-aid contract or completes it by some other acceptable means, the FHWA will consider the terms of the original contract to be in effect and that the work will be completed in accordance with the approved plans and specifications included therein. No further FHWA approval or concurrence action will therefore be needed in connection with any defaulted Federal-aid contract awarded by a surety. Under this procedure, the construction amount eligible for Federal participation on the project should not exceed the amount representing what the cost would have been if the construction had been completed as contemplated by the plans and specifications under the original contract.

§635.127 Agreement provisions regarding overruns in contract time.

(a) Each State transportation department (STD) shall establish specific liquidated damages rates applicable to projects in that State. The rates may be project-specific or may be in the form of a table or schedule developed for a range of project costs and/or project types. These rates shall, as a minimum, be established to cover the estimated average daily construction engineering (CE) costs associated with the type of work encountered on the project. The amounts shall be assessed by means of deductions, for each calendar day or workday overrun in contract time, from payments otherwise due to the contractor for performance in accordance with the contract terms.

(b) The rates established shall be subject to FHWA approval either on a project-by-project basis, in the case of project-specific rates, or on a periodic basis after initial approval where a rate table or schedule is used. In the latter case, the STD shall periodically review its cost data to ascertain if the rate table/schedule closely approximates, at a minimum, the actual average daily CE costs associated with the type and size of the projects in the State. Where rate schedules or other means are already included in the STD specifications or standard special provisions, verification by the STD that the amounts are adequate shall be submitted to the FHWA for review and approval. After initial approval by the FHWA of the rates, the STD shall review the rates at least every 2 years and provide updated rates, when necessary, for FHWA approval. If updated rates are not warranted, justification of this fact is to be sent to the FHWA for review and acceptance.

(c) The STD may, with FHWA concurrence, include additional amounts as liquidated damages in each contract to cover other anticipated costs of project related delays or inconveniences to the STD or the public. Costs resulting from winter shutdowns, retaining detours for an extended time, additional demurrage, or similar costs as well as road user delay costs may be included.

(d) In addition to the liquidated damages provisions, the STD may also include incentive/disincentive for early completion provisions in the contract. The incentive/disincentive amounts shall be shown separately from the liquidated damages amounts.

(e) Where there has been an overrun in contract time, the following principles shall apply in determining the cost of a project that is eligible for Federal-aid reimbursement:

(1) A proportional share, as used in this section, is the ratio of the final contract construction costs eligible for Federal participation to the final total contract construction costs of the project.

(2) Where CE costs are claimed as a participating item based upon actual expenses incurred or where CE costs are not claimed as a participating item, and where the liquidated damages rates cover only CE expenses, the total CE costs for the project shall be reduced by the assessed liquidated damages amounts prior to figuring any Federal pro rata share payable. If the amount of liquidated damages assessed is more than the actual CE totals for the project, a proportional share of the excess shall be deducted from the federally participating contract construction cost before determining the final Federal share.

(3) Where the STD is being reimbursed for CE costs on the basis of an approved percentage of the participating construction cost, the total contract construction amount that would be eligible for Federal participation shall be reduced by a proportional share of the total liquidated damages amounts assessed on the project.

(4) Where liquidated damages include extra anticipated non-CE costs due to contractor caused delays, the amount assessed shall be used to pay for the actual non-CE expenses incurred by the STD, and, if a Federal participating item(s) is involved, to reduce the Federal share payable for that item(s). If the amount assessed is more than the actual expenses incurred by the STD, a proportional share of the excess shall be deducted from the federally participating contract construction cost of the project before the Federal share is figured.

(f) When provisions for incentive/disincentive for early completion are used in the contract, a proportion of the increased project costs due to any incentive payments to the contractor shall be added to the federally participating contract construction cost before calculating the Federal share. When the disincentive provision is applicable, a proportion of the amount assessed the contractor shall be deducted from the federally participating contract construction cost before the Federal share calculation. Proportions are to be calculated in the same manner as set forth in paragraph (e)(1) of this section.

SHELBY COUNTY TENNESSEE
SPECIAL PROVISIONS
STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

STORM WATER POLLUTION PREVENTION PLAN (SWPPP)

The successful bidder on this contract will be required to sign and execute the approved NOI and Storm Water Pollution Prevention Plan (SWPPP).

D-2

SHELBY COUNTY GOVERNMENT

ENGINEERING DEPARTMENT

TRAFFIC SIGNAL SPECIFICATIONS

SECTION D
TRAFFIC SIGNAL SPECIFICATIONS

SECTION 1. GENERAL

1.01 Work Included:

The complete electrical system for traffic signal intersection control as specified herein or as indicated on the plans, consisting generally of, but not limited to: cabinets, conduit, wire, cable, switches, the traffic signal controller, traffic signal heads, and poles. For definition of terms, see General Requirements and Conditions, Section 1, herein.

1.02 Bids:

(1) Each bid shall be accompanied by engineering and operational specifications for the equipment bid. Each bidder may be required to furnish one controller of each type bid with cabinet meeting these specifications for 30 days testing and evaluation prior to award of any contract. If a bidder is requested to furnish sample controllers, they shall be furnished to the Department within 15 days of date requested. If the equipment is not submitted as required, the Department may reject that bid. All material, parts and workmanship shall be guaranteed for a period of one (1) year after field installation with defective equipment either repaired or replaced entirely at bidder's expense.

(2) The successful bidder shall provide, as part of the bid price, a minimum of twenty-four (24) hours of classroom and laboratory instruction on the operation and maintenance of the controllers supplied for three (3) Department technicians. Instructions shall be on a highly technical level, describing the design and operation of electric circuitry in great detail as well as demonstrating trouble shooting and repair techniques. The rudiments of dial systems and basic solid-state theory are below the level of the instruction required by this specification. This instruction shall begin at any time requested by the Department following the contract award and shall be conducted at facilities provided by the bidder. The successful bidder shall provide round-trip transportation from Memphis to the school site and suitable lodging during the school period.

(3) The Department reserves the right to itemize and award separate contracts for the equipment on this bid.

(4) The time of delivery after receipt of an order may be considered along with bid price in the evaluation of bids.

(5) It is the bidder's responsibility to list all exceptions to these specifications on a per item basis. This listing shall not constitute acceptance or rejection of these exceptions by the Department.

(6) Nothing in these specifications shall be construed as being proprietary or discriminatory. References to brand names are used as a quality reference for bidders. Any quotation will be considered if, in the opinion of the Department, the equipment quoted meets this specification.

(7) All equipment shall be described completely with the manufacturer's name, model number, catalog number, and any other identifying information provided with the unit price.

(8) All equipment bid shall be securely packed for shipment so as to avoid damage during transit. All cartons shall be clearly labeled as to their contents, including controller type, and County of Shelby contract number.

(9) The successful bidder(s) shall arrange for the proper expediting, delivery, and shipment tracing, if necessary, of all equipment awarded to them under this specification. Unless directed by the Shelby County Engineer, delivery shall be F.O.B., including inside delivery, to the City of Memphis, Traffic Signal Maintenance Department, 980 South Third Street, Memphis, Tennessee 38106, (Phone Number 901/528-2844).

1.03 Codes and Standards:

All electrical equipment and materials shall conform to the Standards of the National Electrical Manufacturers' Association (NEMA) or the Radio Manufacturers' Association, whichever is applicable. In addition to the requirements of the Specifications, the Plans, and other Contract Documents, all material and work shall conform to the requirements of the National Electrical Code (NEC); the Standards of the American Society for Testing Materials (ASTM); the American National Standards Institute National Electrical Safety Code (ANSI-C-2) the American Standards Association (ASA); U.S. Department of Transportation, Tennessee Department of Transportation Manual on Uniform Traffic Control Devices (MUTCD); Institute of Transportation Engineers (ITE); International Municipal Signal Association, Inc. (IMSA); and any other local ordinance which may apply.

1.04 Accuracy of Data and Drawings:

Electrical plans and drawings are generally diagrammatic, and where not dimensioned or detailed, indicate approximate locations and general arrangements of electrical work. All electrical work offsets, rises, and fittings are not necessarily shown; however, provide these as required by the conditions involved.

1.05 Submittals:

(1) As soon as possible, after award of contract, and prior to purchase of materials, submit to the Engineer for approval a complete list of all proposed material; include with the list complete catalog data and descriptive literature of all materials, if requested.

(2) The supplier shall provide detailed technical circuit description and circuit schematic information applicable to the operation and maintenance of the controller and associated auxiliary equipment. Cabinet wiring diagrams with interconnection details, schematics and maintenance techniques shall be furnished. Information shall be in manual form and shall include a materials guide which shall contain the replacement part numbers and description of all components used. All solid-state devices shall be listed by their generic name or, in lieu of this, a complete cross-index from manufacturer's numbers of generic numbers shall be provided. Parts list shall be itemized with the respective chassis, module or circuit wherein parts may be found. A total listing of parts without grouping shall not be acceptable. Schematic circuit drawings shall be furnished which are slow to fade when exposed to sunlight over long periods of time. A developed and fixed printing process or one of the forms of printing by actual ink transfer will be acceptable. Five (5) copies of all the above information shall be provided for each controller unit. In addition, three (3) copies of a cabinet wiring diagram, including all auxiliary equipment, shall be

supplied with each controller unit. A clear resealable plastic envelope shall be attached with screws to the inside of each cabinet door for storage of the cabinet wiring print. This envelope shall be mounted so as to avoid restriction of the circulation of air into and out of the cabinet.

(3) Upon completion of the work, and prior to final inspection and acceptance, the Contractor shall submit to the Engineer two (2) copies of "As Built" or corrected plans on mylar or linen showing in detail all construction changes, including location and depth of conduit. The Contractor shall also furnish all literature and drawings which are received with the equipment to be installed and which pertain to the engineering installation, operation, warranty, and maintenance of that equipment.

1.06 Maintenance of Traffic

Traffic disruption and delay shall be kept to a minimum, and traffic operations shall be maintained through the project area for the length of the contract. No more than a curb or parking lane may be closed at any one time. The Engineer or his representative may direct special efforts during certain phases of work to ensure compliance with the approved construction schedule. The waiver of restriction, or the imposition of additional restrictions in critical areas of work and traffic flow, may be granted or established by the Shelby County Engineer.

The Contractor may request permission to work at night in accordance with local ordinances and statutes and as approved by the Engineer. When the Contractor performs any operations after daylight hours, he shall provide and maintain, at his expense, sufficient artificial lighting to permit proper construction and inspection.

The Contractor shall be responsible for providing and maintaining adequate safety lights and barricades to protect the public and must maintain access to abutting property. Such protective work shall be done in conformity with applicable portions of the Manual on Uniform Traffic Control Devices (MUTCD), Tennessee Edition. Steel plates of adequate size and strength shall be installed over trenches in street pavements or driveways left open or incompletely backfilled at the end of a work period. Pedestrians and persons alighting from parked vehicles shall be protected against hazards resulting from construction operations.

1.07 Grounding:

Ground electrical equipment and conductors shall be suppled by the Contractors as required by NEC and other applicable electrical codes.

1.08 Wiring Methods:

(1) Electrical systems characteristics shall be as indicated on the plans. In addition, whether indicated or not, provide low voltage (less than 120 volts) wiring for controls and other purposes, as required for the complete electrical system.

(2) Regardless of voltage or use, wiring shall be installed in conduits and metal or other enclosures, unless otherwise indicated or otherwise specified.

1.09 Tests, Service Checks, Inspections, and Documentation:

(1) The Contractor shall be responsible for the installation tests, demonstration of the functioning system, and checks of all hardware.

(2) Conduit Tests.

After installation of the conduit is completed, all conduit installed shall be tested with a mandrel having a diameter 1/2 inch smaller than the conduit and a length of 2 inches. All conduit which will not allow passage of the mandrel shall be repaired to the satisfaction of the Engineer; if repairs cannot be made, the conduit shall be removed and replaced at no additional cost to the County. After the mandrel test, all conduit shall be scoured with a stiff wire brush slightly larger in diameter than the conduit. The Contractor shall clear all conduit in the presence of the Engineer.

(3) Field Tests

Prior to completion of the work, the Contractor shall cause the following tests to be made on all traffic signal circuits in the presence of the Engineer. Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner approved by the Engineer, and the same tests shall be repeated until no fault appears.

(4) Ground Test.

Each circuit shall be tested for grounds in the circuit.

(5) Megger Test.

A megger test shall be made on each circuit between the circuit and ground. The insulation resistance shall not be less than the values specified in Section 19 of the NEC. The load in amperes of each signal circuit shall be measured at the controller cabinet with a clamp-on ammeter. If the amperage is in excess of the expected lamp load plus minimal transmission losses, the circuit will not be accepted and shall be replaced or corrected by the Contractor at no additional compensation.

(6) Functional Test.

A functional test shall be performed in which it is demonstrated that each and every part of the system functions as specified or intended herein. Signal circuits shall be "flashed out" from the cabinet terminals to determine that the proper function has been assigned each circuit.

(7) Detector Ground Test.

All detector loops and leads shall be tested before and after they are sealed in the pavement to be sure there are no shorts to ground in the system and to assure that the loop plus lead-in inductance is within the operating range of the detector, all according to the Standards on Loop installation.

(8) Inspection

All work and materials to be performed or finished under these specifications shall be subject to observation and inspection by the Engineer according to Section 1112 of this Contract Document Book. Request for an Engineer or Inspector in connection with work under these Specifications shall be made by the Contractor at least twenty-four (24) hours before the services thereof will be required.

(9) Mill Test Reports and Certification.

Mill Test Reports or Certifications of Specifications for Materials and Design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the materials:

a. "Mill Test Reports" (M.T.R.) for MAJOR structural items only, as noted in Table, shall include both physical and chemical descriptions of the materials as supplied to the fabricator. When physical properties are altered during the fabrication, M.T.R. covering chemical composition will be supplemented by certified test reports indicating the physical properties of this material after fabrication.

b. Certification of conformance to the Specifications for all remaining material not covered by M.T.R. as noted in Table.

c. Certification that all welding was performed by operations qualified as follows: Steel welders to AWS and aluminum welders to ASME.

d. Certification of conformance to the Specification for design of all components not completely dimensioned and detailed in the Design Standards.

TABLE

MILL TEST REPORT AND CERTIFICATION OF CONFORMANCE REQUIREMENTS

Component Materials	M.T.R.	Certification
Tubes for arms and poles	X	
Base castings	X	
Anchor Bolts	X	
Pole tops, miscellaneous fittings and hardware		X
Fabricated or cast-type arm connections		X
Galvanizing		X
Signal cable and wire		X
Loop Sealant		X
Concrete	X	

(10) Until such time as the Department has made final acceptance, fixture heads shall remain concealed from view of approaching traffic by means of heavy, opaque plastic or canvas cloths, draped over and securely attached to heads.

1.10 Documentation of Traffic Signal Controller/Cabinet:

The Contractor shall furnish to the Engineer one set of the documentation described in page of these Specifications for each traffic signal controller/cabinet installed.

1.11 Guarantee:

The traffic signal system(s) installed under these specifications, including all equipment, parts and appurtenances in connection therewith, shall be guaranteed to Shelby County by the Contractor against defective workmanship and materials for a period of not less than one year following the

date of acceptance thereof. Upon completion of the project, warranties or guarantees on equipment and materials that are offered by the manufacturers as normal trade practice and have not expired shall be turned over by the Contractor to the Engineer.

1.12 Removal and Salvable Equipment:

Utility companies will be responsible for the relocation and/or removal of their poles and equipment. The poles, equipment, and other items to be removed by the Contractor have been generally noted on the Plans; however, it is the intent of these Specifications to have the Contractor remove any traffic control-related items that are in conflict with the installation of the proposed signal and stockpile it on the project site as directed by the Engineer to be picked up by the local municipalities. This includes but is not limited to signal poles, controllers and cabinets, pullboxes, signal heads, and signs. All items so designated or directed to be removed, upon placing in operation new or temporary signals, shall be removed and stockpiled in such a manner that the removed equipment will not be damaged. Poles shall be removed complete and undamaged. The pole shall be cleaned of any concrete foundation material. Any damage due to negligence on the part of the Contractor because of lack of proper care and equipment shall be cause for Shelby County to order its replacement. The cost of such replacement shall be borne fully by the Contractor without extra compensation. All such removed and salvable equipment is now and shall remain the property of the municipality from which it was removed.

SECTION 2. EXCAVATION AND BACKFILL

2.01 Excavation:

The Contractor shall excavate and backfill, as required, for the electrical work. He shall cut bottoms of trenches to the proper lines and grades to provide firm and continuous support for the underground electrical work, and to provide 24" MINIMUM depth from finished grade to tops of all exterior underground electrical work. Sheet and brace excavations, as required, to protect personnel and adjacent structures.

2.02 Backfill:

After the underground electrical work has been installed and approved, the Contractor shall place backfill in 8" maximum thickness loose layers, and compact each layer to at least the density of the adjacent undisturbed site soil using pneumatic or other suitable power tampers. Mass backfilling (backfilling without tamping) is prohibited.

SECTION 3 CONDUITS AND FITTINGS

3.01 General:

Metallic or plastic conduit may be used for all installations except non-metallic conduit shall be used for ground wire raceways in pole foundations and. Conduit size shall be taken as the inside diameter.

3.02 Materials:

(1) Metal conduit and fittings shall be rigid heavy-walled, hot-dipped galvanized steel and shall comply with the latest edition of Underwriters Laboratories' Standard UL 6, Federal Specification WW-C-581 and American National Standards Institute C 80.

(2) Plastic conduit (PVC) shall be heavy-walled, extruded moisture and oilproof polyvinylchloride, corrosion resistant, with watertight joints and high impact strength. Conduit and fittings shall be in accordance with NEMA TC-2 and WC-1094 Specifications, UL listed.

3.03 Installation - General:

(1) Jacking and boring shall be accomplished by approved jacking and drilling methods that will not disturb the pavement. Jacking and drilling pits shall be kept at least two (2) feet clear of the edge of any type pavement whenever possible. Use of water that may cause undermining of the pavement will not be permitted. Excavation and backfilling incidental to the operation will not be paid for separately.

(2) The Contractor shall remove all excess dirt, asphalt, concrete, etc., following installation and acceptance of conduit. Sod shall be placed after inspection to match surroundings.

(3) Metallic conduit shall be properly threaded and reamed with wire entrances protected by bushings and shall be grounded. Where more than one metallic conduit enters a pull box, cabinet, or foundation, bonding shall be accomplished by the use of straps and jumpers. Bends and offsets shall be avoided where possible, but where necessary, shall be made with a proper hickey, pipe bender, or conduit bending machine. Article 346 of the National Electrical Code shall govern metallic conduit installation.

(4) Equipment and methods recommended by the manufacturer shall be used in field bending of non-metallic conduit. This shall include the use of plugs where recommended. Conduit which has been crushed or deformed due to improper bending or handling shall not be installed. Article 347 of the National Electrical Code shall govern non-metallic conduit installation.

(5) Threads on metal conduits shall be clean cut, straight, and true, and of sufficient length to permit proper coupling; long running threads will not be permitted on any part of the work. Threads shall be protected in transit and during installation, and conduit shall be provided with proper supports and protection during construction to prevent damage to the threads. All ends of pipe installed for future connections shall be properly threaded, reamed, and capped to prevent water and foreign matter from entering the conduit system. Sections shall be made up with pipe dope so that ends of conduit will abut. Threaded ends in pull boxes and foundations shall be provided with approved conduit bushings. All joints shall be sealed with pipe dope for a waterproof installation.

(6) All bends into pull boxes and foundations shall be free from kinks and of such easy curvature to permit the drawing in of cables without damage to insulation. Conduit between pull boxes, foundations, and poles shall be placed in a straight line, unless otherwise shown in the Plans.

(7) After installation of the conduit is completed, all conduit installed shall be tested with a mandrel having a diameter 1/2 inch smaller than the conduit and a length of 2 inches. All conduit which will not allow passage of the mandrel shall be repaired to the satisfaction of the Engineer; if repairs cannot be made, the conduit shall be removed and replaced at no additional cost to the County. After the mandrel test, all conduit shall be scoured with a stiff wire brush slightly larger in diameter than the conduit. The Contractor shall clear all conduit in the presence of the Engineer.

(8) All conductors, except sawed loop detector conductors and span wire runs (as shown on the Plans), shall be run in conduit, except where the run is inside poles. Where signal conductors are run in standards containing high voltage (over 600 volts) street lighting conductors, the lighting conductors shall be disconnected and encased in flexible metal or rigid metal conduit.

(9) Conduit shall be laid to a depth of not less than 36 inches below pavement grade, unless otherwise approved by the Engineer, except conduit may be laid at a depth of not less than 24 inches below top of curb when placed behind the curb. Conduit runs shall be located as shown on the Plans or as directed otherwise by the Engineer.

(10) Conduit sizes will be indicated on the Plans. Signal conduit shall be a minimum of 2 inches in diameter and detector conduit a minimum of 1 inch in diameter, unless otherwise indicated. Conduit for service connections shall be 2 inches in diameters. Conduits smaller than 1 inch diameter shall not be used unless otherwise specified, except grounding conductors at service points shall be enclosed in 3/4 inch diameter PVC conduit. The Contractor may, at his own expense, use larger size conduit than specified, in which case it shall be for the entire length of the run with no reducing couplings permitted.

(11) Conduit terminating in anchor base standards and pedestals shall extend approximately 6 inches above the foundation and shall be sloped toward the handhole opening. Conduit shall enter concrete pull boxes from the bottom and shall terminate not less than 2 inches nor more than 4 inches above the bottom of the box and near the box walls to leave the major portion of the box clear. All such metal conduit terminations shall be fitted with a grounding bushing to protect the cable jackets and to bond the conduits into the ground system in accordance with the Plans.

(12) Existing underground conduit to be incorporated into a new system shall be checked with a mandrel and scoured the same as new conduit, all in the presence of the Engineer.

(13) An approved rope or snaking device shall be placed in all conduit (new and reused) following mandrel and scouring for use in pulling in pull ropes for installing the wiring cable of conductors. A 2-inch mandrel 1/2 inch smaller in diameter than the conduit shall be passed through the entire length of the conduit immediately before installation of cable.

3.04 Installation of Jacked Underground Conduit:

Conduit under existing pavement shall be placed by an approved jacking or drilling method. Existing pavement shall not be disturbed unless otherwise directed by the Plans or by the Engineer.

3.05 Installation of Conduit Risers:

Conduit risers shall be fitted with condulets and a weatherhead, and attached to the poles as shown on the Plans or Design Standards.

3.06 Installation of Conduits under Streets and Driveways:

All conduits installed under streets and existing driveways shall be placed in accordance with the Plans or as approved by the Engineer. No more than one-half of street width may be closed to traffic at any one time. Temporary bridging of narrow trenches with suitable steel plates will be permitted if requested in the Contractor's schedule of operation plans. Existing pavement surfaces shall be removed to neat lines. Pavement patches shall conform to the details shown in

the Plans for areas where future improvements, like material and methods, will be used for replacement unless, otherwise directed by the Engineer. Finished grade shall conform to the surrounding pavement and shall present a smooth riding surface when completed.

The Contractor shall maintain the patched trench by adding or removing asphaltic concrete paving materials as directed by the Engineer until a stable, smooth crossing is obtained.

SECTION 4. WIRE, JOINTS, AND SPLICES 600 VOLTS AND LESS

4.01 Type of Wire:

Lighting and power wires shall be copper only. Types shall be:

(1) Where type is indicated: Indicated type only.

(2) High temperature and other special conditions: Types NEC approved for the conditions involved.

(3) Exposed flexible cords: Type SO, with grounding conductor.

(4) Direct earth burial: Type USE, with neoprene jacket.

(5) All other lighting and power wire: Type THW.

(6) Ground conductors: Copper only.

4.02 Control Wire:

Control wire shall be type MTW copper, stranded.

4.03 Copper Wire:

Where sizes of copper wire are neither indicated nor otherwise specified, copper wire sized shall be:

(1) Branch circuit wire: No. 12.

(2) Control Wire: No. 14, or as recommended by the control manufacturer.

(3) Special system wire: As recommended by the manufacturer or the equipment involved.

4.04 Identification:

(1) General: All wires shall be identified, as required by NEC.

(2) Control and special systems wire: These shall be color coded throughout, or identified at each terminal and junction point with a suitable permanently attached tag or label.

4.05 Joints and Splices:

All joints and splices shall be made with suitable solderless connectors, in the various boxes,

gutter, and similar locations, but not in any conduit. Enough wire shall be left slack to permit at least one splice or joint to be remade in case of fault.

(1) Branch circuit, control, and special system copper wire joints: Use Ideal, Buchanan, 3M, or similar tool-applied or twist-on type connectors.

(2) All other copper wire joints: Use Ilsco tin-plated aluminum type pressure connectors, or suitable brass, bronze or copper pressure connectors.

(3) All joints and splices shall be insulated with suitable sleeves or caps integrated with the connectors or separate therefrom, or with vinyl plastic insulation tape.

SECTION 5. SERVICE

5.01 General:

Contractor shall arrange with local utility to provide electrical service to new controller locations. Contractor shall terminate feeders at pole leaving 6'-0" free ends for connection to electric service by utility.

SECTION 6. TRAFFIC SIGNAL CONTROLLER

6.01 General. This section describes the general and specific construction and operating requirements of new local intersection traffic signal controllers, cabinets, and related equipment to be furnished by the Contractor.

This section contains design requirements for controllers, controller interface, physical standards, functional standards, and coordination standards.

The control equipment described herein is to be used in operating traffic signals as part of a coordinated system. The local control equipment shall be fully compatible with the signal system and central software supplied as called for in other sections.

All definitions contained in *NEMA Standards Publication No. TS1-1989* (hereinafter referred to as the NEMA) shall apply.

The Contractor shall install all local controller databases, including coordination timing and scheduling, using data furnished by the Engineer in standard, traffic engineering terminology.

6.02 New Local Intersection Controllers.

(1) General. All new local intersection traffic signal controllers shall be a fully-actuated, two-through-eight phase, four-ring solid-state, digitally-timed traffic signal controller. Each model of new controller furnished by the Contractor shall be a proven controller and not a pre-production prototype.

The controller shall be of modular design with an internal power supply all mounted in a suitable sheet metal enclosure. The metal chassis shall be designed for easy access to the printed circuit

boards. All pin connectors shall be front mounted.

(2) Required Phase Sequences. Each new controller furnished by the Contractor shall be fully capable of providing, as a minimum, all standard NEMA phase sequences, all phase sequences shown on the plans. The local controllers, in combination with the central software, shall provide for coordination of each of these required phase sequences and for the independent programming of each odd- numbered phase (i.e., 1, 3, 5 and 7) to be either leading or lagging with respect to its corresponding even-numbered phase (i.e., 2, 4, 6 and 8).

(3) Specific Design Requirements.

(i) *Modules*. The design shall allow for easy removal or replacement of all modules without the use of special tools.

(ii) *Circuitry*. The controller circuitry shall consist of a high threshold solid-state digital electronic design. The circuit components shall be standard production types that are typically available from industrial electronic supply houses. The circuit and component design life under continuous duty operation shall not be less than ten years. All controllers shall employ high quality solid-state, modular electronic construction designed for continuous unattended operation. No electro-mechanical devices such as camshafts, rotary stepping line switches, lightning discharge tubes, or vacuum or gaseous tubes shall be used for internal or external auxiliary circuitry.

(iii) *Equipment Housing*. The controller shall be a completely enclosed in a metal or high-impact plastic case which is easily removed and replaced. If not metal, the inside of the case shall be sprayed with a conductive film. The design shall include screened or recessed vent holes. The model and serial number shall be securely affixed to the outside of the housing.

(iv) *Fuses*. All equipment shall be individually fused with protection devices that are panel-mounted on the front face of the equipment. Fuses shall be provided for both the 120 VAC and 24 VDC power.

(v) *Controller Expansion/Modification Capability*. Controller shall be provided to operate as a two (2) through eight (8) phase controller. The controller design shall permit the mode of operation to be changed and the vehicle and pedestrian phasing capacity to be increased without requiring that the controller case be internally modified or rewired. The motherboard and power supply shall be of adequate design to service the maximum configuration of the controller.

(4) Required Features.

(i) *Per-Phase Features*. The following per-phase features shall be provided:

- Extended flashing ped clearance
- Actuated rest in walk
- Soft vehicle recall
- Selective phase omit
- Selective phase yellow omit
- Conditional service
- Detector (stretch, delay and switching)

(ii) *Per-Unit Features*. The following per-unit features shall be provided:

- Programmed (remote) flash
- Exclusive ped service
- Ring configurations (to 4 rings)
- Start-up flash or all red
- Remote sequence modifiers (16)
- Timed trailing overlaps
- Overlap green/yellow omit
- Auto timing of ped clear
- Resident diagnostics
- Parameter printout
- Unit-to-unit transfer

(iii) *Coordination*. As a minimum, the following coordination features shall be provided:

- 4 Dial/4 Split/3 Offset
- 48 traffic patterns
- 3 offset correction modes
- Transition cycles
- Auto permissives (vehicle and pedestrian)
- Sync monitoring
- Manual control
- Input monitor (walk rest modifier, manual control enable, stop time, remote flash)
- Dial/split to dial/split copy

(iv) *Time Base*. As a minimum, the following time base scheduler features shall be provided:

- Primary plus two alternate weeks
- 90 alternate days
- 180 event capacity
- Dimming (per phase by phase output)
- Auxiliary outputs, minimum of four (4)
- Max II selection per phase TOD
- Phase omit TOD
- Automatic or user-programmable daylight savings time and leap-year adjustment

(v) *Preemption*. A minimum of six (6) preempt sequences, each with the following features, shall be provided:

- Delay and duration (multiple runs)
- Programmable sequence
- Programmable flash override
- Programmable priority

The Contractor shall program and make operational all preemption sequences called for in the plans.

(vi) *Special Detector Capabilities*. The controller shall have the ability to assign, modify, and view detector operational parameters of all detector inputs to the controller. Detector operations shall be assigned as follows:

- A standard vehicle detector
- A standard pedestrian detector
- A 1-calling vehicle detector where the input shall operate as a vehicle detector that is operational while the phase is not green and the phase is on locking detection.
- A stop bar detector that shall operate as a vehicle detector which operates normally until it is in its phase green. In the green, the detector is disconnected and does not input to the phase. This feature is to operate in either lock or non-lock operation.
- A stop bar detector whose input shall operate as a vehicle detector that operates normally when the assigned phase is not green. When a call is detected, it shall be held in green until a gap greater than the Extend Timer setting occurs. The Extend Timer shall begin with the green. If a call is received before the Extend Timer times out, it shall be reset. Timer reset shall continue to occur until a gap is large enough to allow the Extend Timer to time out. Once a time out occurs, the detector shall be disconnected until the green terminates. When the extend time setting is zero, a call shall be held in green until a gap occurs. Delay time is to function normally.
- Ability to switch detector actuations to another phase when the assigned phase cannot be serviced normally or is red or yellow and the entered phase is green.
- Delayed actuations, selectable from 0-99.9 sec. in 1/10th sec. increments.
- Extended actuations, selectable from 0-99.9 sec. in 1/10th sec. increments.

(vii) *Special Features*. As a minimum, the following special features shall be provided:

- Eight (8) system detector/coordination inputs
- Detector diagnosis
- Detector assignments and special detector allocation
- Speed report
- Measurements of effectiveness

  - ☐ Green utilization
  - ☐ Time waiting
  - ☐ Cars waiting
  - ☐ Volume

- Controller local alarm log

  - ☐ The log shall be accessible from the keyboard
  - ☐ It shall have the ability to store up to 80 alarms, of the following types, and showing the date and time of occurrences:

    - -- On-line/off-line
    - -- Power on/off-interrupt
    - -- Preemptions and user definable alarms
    - -- Low battery check/replace
    - -- Watchdog timeout
    - -- EPROM write/failure counts

- -- RTC chip failure/fault/adjust
- -- Alarm/Comm/TrafResp./Speed/ MOEs/Detector log faults
- -- Diagnostics
- -- Coord status and Local/Free
- -- Software clock adjust
- -- Time change remote/keypad

- ☐ Alarms shall appear in the order in which they occur. It shall be able to store up to 80 of the latest alarms with any additional alarms replacing the oldest.

- Remote selected special functions
- Remote "Manual" overrides
- TBC on loss of communications
- Upload and download data
- Communications

(5) Miscellaneous Requirements.

(i) All input data shall be user-programmable by means of the keyboard and LCD display. All internal time setting shall be programmed via a 16 position keypad and stored in a removable EEPROM memory program pack. Programming shall be facilitated by the use of menu driven displays in English terms. Data entry and interrogation of the controller shall be made easy by listing instructions in English on the display so that codes or reference manuals are not required.

(ii) All controllers shall be provided capable of coordinated control. Any phase of a multi-phase controller shall be capable of being the coordinated phase with any or all 16 timing plans.

(iii) The controller shall have one and only one set of master digital clocks to time all intervals of all phases. Separate clocks associated with and/or located on individual phase boards are prohibited.

(iv) The control unit enclosure shall bear a name plate plaque with an ingrained identifying serial number, model number, and manufacturing date code.

(v) All printed circuit boards shall be of fiberglass - epoxy construction with a minimum of two (2) ounce copper circuit track and comply with NEMA.

(vi) All controller unit input and output integrated circuit components shall be socket mounted to facilitate repair and maintenance of input/output boards. Also, all CPU board integrated circuit components with 14 or more leads shall be socket mounted.

(vii) The control unit shall be furnished consistent with a standard model designation and registration and it shall be completely interchangeable with other units of the same model and type, as well as with other controllers which comply with NEMA Section 13.

(viii) The controller shall be furnished with dual maximum on all phases. The second maximum limit shall be timed by internal controller circuitry. No external timers shall be permitted. The selection of maximum limit 1 or 2 shall be by either remote selection, internal time base, or time clock(s), and with selection of the maximum limit 1 or 2 for a particular phase being independent of the selection of maximum limit 1 or 2 for any other phases.

(ix) The control unit shall be furnished with a liquid crystal (minimum 8 line by 40 characters per line) alpha-numeric display for parameter entry and viewing. The display shall present current real-time status of active timers and/or states per ring for two rings simultaneously. All status indicators shall be presented in abbreviated English NEMA recognizable terms.

(x) Digital timing utilizing the 60 Hertz frequency of the electrical service line as a counting

reference shall be used for all intervals. Any interval shall not deviate more than 0.100 seconds from its true time setting.

(xi) The control unit shall have a self-contained power supply to operate the controller and all auxiliary equipment. The power supply shall operate from an electric service line with input voltage from 95 to 135 volts, 60 Hertz, and develop stabilized controller voltages for continuous controller operation with interval timing remaining within specified tolerances. The power supply shall be separately and independently fuse protected for both the 120 VAC input and 24 VDC output with easily accessible fuses. Internal fuses are not permitted. DC output for external circuitry shall be rated at a minimum of 0.5 amp and capable of direct short circuit without internal damage to the power supply. All components of the power supply shall be amply derated with respect to heat dissipating capacity so that any extreme ambient temperature and applied voltage shall result in neither a material shortening of component life or a severe deterioration of operational characteristics. The power supply shall be capable of operating the controller when expanded to its maximum capabilities complete with all auxiliary equipment. No auxiliary or external power supplies permitted.

(xii) All controller input and output logic levels shall be a nominal zero volts (logic ground) for the true state and nominal +24 volts for the false state.

(xiii) The controller shall conform to requirements of "Environmental Standards for Test Procedures." No cabinet surge protection or line filters shall be considered in providing the required transient protection.

(6) Parts Lists and Cross-Referencing. The Contractor shall provide a detailed technical circuit description and circuit schematic information applicable to the operation and maintenance of each type of controller and associated auxiliary equipment. Cabinet wiring diagrams with interconnection details, schematics and maintenance techniques shall be furnished. Information in manual form shall include a materials guide, which shall contain the replacement part number and description of all components used.

All solid-state devices shall be listed by their generic name or in lieu of this, a complete cross index from manufacturers numbers to generic number shall be provided. Parts lists shall be itemized with the respective chassis, module or circuit wherein parts may be found. A total listing of parts without grouping shall be unacceptable. Schematic circuit drawings of a type which is slow to fade when exposed to sunlight over long periods of time shall be furnished. A developed and fixed printing process or one of the forms of printing by actual ink transfer will be acceptable. Three (3) copies of all the above information shall be provided for each ten (10) or partial group of ten (10) like controller units furnished. In addition, a photo mylar master of a cabinet wiring diagram including all auxiliary equipment shall be supplied with each control cabinet type.

(7) Software and Software Updates. The Contractor shall furnish a certification from the controller manufacturer that the controller software will be updated as revisions are available. One (1) copy of the latest computer system software for an IBM-compatible microcomputer shall be furnished by the Contractor. The certification will assure that this copy will be updated by the controller manufacturer so that both the traffic controllers and the computer are operating on compatible software. The certification shall state that this software update service will be provided at no future cost to the Department or the City.

6.03 Internal Communications Transceiver.

(1) General. Each new local controller furnished by the Contractor shall have an internal communications transceiver which shall receive system commands and data from the central system and transmit local intersection status data, database, and system detector data to the central system.

(2) Functions Monitored. As a minimum, the following functions shall be monitored and the status of each transmitted to the central system:

(i) All vehicular signal indications for each active phase and green, yellow, and red indications for a minimum of four (4) overlaps.

(ii) All pedestrian indications for a minimum of four (4) active phases. WALK, flashing DONT WALK, and steady DONT WALK shall be monitored.

(iii) Vehicle and pedestrian actuations for each active phase.

(iv) Timing plan in effect.

(v) Cycle countdown.

(vi) Status of all local special functions, including the "door-open" alarm required per Subsection 5.1.2 of the specifications.

(vii) Operational status of the intersection (in coordination, in transition, free operation, flash, local manual control or preempted).

(3) Data Transferred. The communications transceiver shall receive from the central system command data including, minimally, the following:

(i) Timing plan commands.

(ii) Local special function commands (minimum of four).

(iii) Coordinated or free mode.

(iv) Request for local data response.

(v) System clock update

(4) Database Downloading/Uploading. The communications transceiver shall permit downloading and uploading of the entire local intersection database, including coordination and TBC, to/from disk storage at the central facility.

(5) Design Standards. The communications transceiver's connector shall not be interchangeable with any other connector in the local controller cabinet. As a minimum, the communications transceiver shall provide the following features:

(i) Time division multiplexing/frequency shift keying techniques.

(ii) Two-way communications over agency-owned cable.

(iii) Parity and error checking diagnostics to assure transmission/reception of valid data.

(iv) Appropriate indicators including, but not limited to, transmitting and carrier reception.

(v) Local address assignment.

(vi) Transmitter output level which is either user adjustable to a maximum of zero (0) dB or automatically maintained within the range of 0 to 3 dB continuous.

(vii) Transmitter frequency stability of ±5 Hz over the NEMA operating temperature range.

(viii) Receiver in-band signal-to-noise ratio of +10 dB or greater.

(ix) Receiver input common mode rejection of greater than 40 dB.

6.04 Internal Fiber Optic Transceiver. Each new controller shall have an internal fiber optic transceiver which fully complies with requirements set forth in Subsection 6.03. Each such fiber optic transceiver shall either be an OTR/RP or an OTR/LT as required for the application called for on the plans.

6.05 New Traffic Signal Controller Cabinets.

(1) Cabinet Material.

(i) Pole-mounted cabinets and pedestal-mounted cabinets shall be fabricated from cast aluminum or welded sheet aluminum or a combination of both. All welds shall occur on the inside surface of the cabinet to maintain a clean appearance.

(ii) Base-mounted controller cabinets shall be fabricated from welded sheet aluminum. All welds shall occur on the inside surfaces of the cabinet to maintain a clean appearance.

(iii) All new controller cabinets shall have an unpainted natural aluminum finish.

(2) Doors. Cabinets shall have a right hinged front opening door, which shall include, substantially, the full area of the cabinet front and one (1) auxiliary police door-in-door for access to emergency controls. The main door shall be equipped with a positive hold fast device to secure the door in at least two open positions being approximately 90 degrees open and the other at 120 degrees or more. The hold fast device shall be easily secured and released without the use of tools. Each door shall be furnished with a neoprene rubber door sealing gasket to assure the weatherproof integrity of the cabinet doors when closed. The main cabinet door shall employ two or three heavy duty hinges which shall be welded to or an integrally cast part of the cabinet and door. Hinge pins shall be 6 mm diam. stainless steel. No "piano" hinges or riveted construction shall be acceptable. The police panel door shall employ hinges meeting the above requirements.

The main cabinet door shall have a switch wired to activate "door-open" alarm input into the controller. This alarm shall be active whenever the main door is open.

(3) Locks and Keys. The main door shall have a Corbin pin-tumbler cylinder lock, conforming to the City of Memphis master key; the Memphis key code shall be furnished to the Contractor after award of contract. The auxiliary police door shall be furnished with a standard police sub-treasury lock. One (1) key for each lock shall be provided with each controller cabinet.

(4) Mounting Hardware.

(i) Base-mounted cabinets shall be installed on a concrete foundation using Contractor-

furnished hot dip galvanized bolts, nuts, and washers.

(ii) Pole-mounted cabinets shall be equipped with brackets (two each) for 19 mm wide stainless steel banding. The Contractor shall attach such cabinets to wood or steel poles using food service grade stainless steel banding which has minimum thickness of 4.5 mm.

(iii) Pedestal-mounted cabinets shall be furnished with a galvanized slip-fitter sized appropriately for the existing pedestal post. The bottom of pedestal-mounted cabinets shall be reinforced as necessary to prevent wobble and/or excessive flexing when the cabinet is attached to the pedestal post.

(5) Fans and Ventilation. All cabinets shall be furnished with a thermostatically operated roof-mounted electric exhaust fan. All cabinets shall have fans rates at 5.66 cubic meters per minute at 38 degrees Celsius. The fan shall be equipped with long lasting permanently lubricated bearings for constant unattended operation. The exhaust fan shall be mounted in a rain-tight housing attached to the cabinet top. The thermostat shall be adjustable from 20 degrees Celsius to 70 degrees Celsius.

In all cabinets, the inlet ventilation openings shall be located in the lower part of the cabinet door, shall be screened and fitted with a fiberglass, furnace-type replaceable air filter of adequate size and capacity to pass a volume of air equal to or greater than the rated capacity of the fan. The air filter supplied shall be a type and size which is readily available commercially.

(6) Surge Protection.

(i) *Electromechanical Relays*. Each 120 VAC electromechanical relay in the cabinet, flash transfer, signal monitor, etc., shall be suppressed with an R. C. circuit (100 OHM/0.1 MAD) across it to ground.

(ii) *AC Service*. The cabinet AC service shall be provided with the following surge protection:

- Unit shall be a series hybrid type rated at 20,000 amps (8 x 20 microsecond) 20 times.

- The protector shall be provided with terminals as defined below:

  - ☐ Main line (AC line first stage terminal)
  - ☐ Main neutral (AC neutral input terminal)
  - ☐ Equip line in (AC line second stage input terminal, 10 amps)
  - ☐ Equip line in (AC line second stage output terminal, 10 amps)
  - ☐ Equip neutral out (neutral terminal to protected equipment)
  - ☐ GND (earth connection)

- The equip line in and equip line out terminals shall be separated by a 200 microhenry (minimum) inductor rated to handle 10 amps AC service.

- The first stage clamp shall be between main line and GND terminals.

- The second stage clamp shall be between equip line out and equip neutral.

- Main neutral and equip neutral out shall be connected together internally

and shall have a gas discharge tube rated at 20 kA between main neutral and GND terminals.

- Main line and equip line terminals shall be isolated internally.
- If gas discharge tubes are utilized for the first stage clamps, each tube shall have a minimum of 0.15 OHM follow-current limiters in series.
- Peak clamp voltage: 350 volts at 20 KA. (Voltage shall be measured between equip line out and equip neutral out terminals. Current shall be applied between main line and GND terminals with GND and main neutral terminals externally tied together.)
- Response time: voltage as measured during peak clamp voltage test can never exceed 350 volts.
- Protector shall be epoxy encapsulated in a flame-retardant material.
- Continuous service current -- 10 amps at 120 VAC RMS.

(iii) *Solid-State Load Switches*.

- Each AC+ signal display terminal shall withstand a 10 kA, (8 x 20 microsecond surge) 5 times without damage.
- Unit response time shall be less than 50 nanoseconds.
- Maximum clamping voltage shall be 395 volts (at 1 mA).
- Unit shall return to a high impedance state following surge.
- Unit shall be epoxy encapsulated in flame retardant material.

(iv) *NEMA 24 VDC Inputs*. Each 24 VDC input that leaves main controller cabinet, (such as ped detector, remote vehicle detector, logic common, etc.) shall be protected at the cabinet entry point with the following surge protection:

- Unit must be a two stage hybrid type.
- The signal pair must "pass thru" the protector so that the protector has an input lead, and output lead, and a ground connection.
- Peak surge: 4000 amps, 8 x 20 microsecond waveform.
- Number of occurrences: 25 times minimum at 2000 amps. 8 x 20 us. protector shall be operative after this test.
- Unit first stage shall be a two element gas discharge tube rated at 5 kA (8 x 20 US).
- Unit second stage shall be 1500 watt silicon avalanche device with a clamp voltage of 45 volts max. at 2000 amps.

- Unit shall be epoxy encapsulated.

(v) *Vehicle Detectors*. Each vehicle detector input circuit (at cabinet entry point) shall be equipped with the following surge protection:

- Unit shall be a three terminal device capable of protecting the detector against differential (between the loop leads) surges, and against common mode surges (between leads and ground).
- Unit shall withstand six 400 amp (8 x 20 US) differential mode surges and six 1000 amp (8 x 20 US) common mode surges.
- Unit shall clamp both common mode and differential mode surges at 35 volts maximum in less than 40 nanoseconds.
- Differential (between loop leads) capacitance of the protector shall be less than 50 microfarads.
- Unit shall be epoxy encapsulated.

(7) Radio Interference Suppressor. The cabinet shall be equipped with a radio interference filter installed at the electric service line input. The filter shall provide a minimum electrical noise attenuation of 50 decibels over the range of 200 kilohertz to 75 megahertz.

(8) Preemption Isolation Relays. At intersections where the plans call for preemption, an isolation relay shall be provided for each separate preempt input.

Railroad preemption, where called for on the plans, shall provide fail-safe operation such that removal of voltage from the railroad cabinet-side of the isolation relay shall remove an input to the controller and thereby initiate the railroad preemption sequence.

(9) Pin Connectors. Electronical connections between the control unit and the cabinet wiring harness(es) shall be accomplished using one or more "MS" type multiple pin connectors at the controller (NEMA type) and insulated spade wire terminal connectors at the cabinet terminal blocks. The pin connectors and function pin assignments shall be in accordance with Tables 1, 2, and 3. All functions developed within the control unit for existing or future expanded phasing, up to the maximum capability of the controller, shall be available at the cabinet terminals for greatest operational flexibility. All functions and pin assignments required by NEMA shall be provided as a minimum. Additional functions and features either required by these specifications or offered by the manufacturer, shall be provided through the pin connector on otherwise spare positions.

Additionally, end controller unit shall be provided with one RS 232 connector with pin assignments as follows:

PIN	FUNCTION
1	Frame Ground (FG)
2	Transmit Data (TD)
3	Receive Data (RD)
4	Request To Send (RTS)
5	Clear To Send (CTS)

6	Not Used
7	Signal Ground (SG)
8	Data Car Det. (DCD)
20	Data Term Rdy (DTR)

TABLE 1

CONNECTOR A
Alphabetical Listing of Pin Assignments

Pin	Function	Pin	Function
A	Spare 1	AA	Test Input B
B	+24V DC External	BB	Walk Rest Modifier
C	Voltage Monitor Output	CC	Coded Status Bit A Ring
D	Phase 1 Red Driver	DD	Phase I On
E	Phase 1 Don't Walk Driver	EE	Phase 1 Ped Omit
F	Phase 2 Red Driver	FF	Ped Recycle Ring 1
G	Phase 2 Don't Walk	GG	Max 2 Selection-Ring 1
H	Phase 2 Ped Clear	HH	Spare 5
J	Phase 2 Walk		
K	Phase 2 Vehicle Call Det		
L	Phase 2 Ped Call Det		
M	Phase 2 Hold		
N	Stop Timing Ring 1		
P	Inhibit Max Term Ring		
R	External Start		
S	Interval Advance		
T	Spare 2		
U	AC-		
V	Chassis Ground		
W	Logic Ground		
X	Flashing Logic Output		
Y	Coded Status Bit C Ring 1		
a	Phase 1 Yellow		
b	Phase 1 Ped Clear		
c	Phase 2 Green		
d	Phase 2 Check		
e	Phase 2 On		
f	Phase 1 Vehicle Call Det		
g	Phase 1 Ped Call Det		
h	Phase 1 Hold		
i	Force Off Ring 1		
j	Ext Min Recall All Phases		
k	Manual Control Enable		
m	Call to Nonactuated I		
n	Test Input A		
p	AC+		
q	Spare 3		
r	Coded Status Bit B Ring 1		
s	Phase 1 Green		
t	Phase 1 Walk		
u	Phase 1 Check		

v	Phase 2 Ped Omit
w	Omit All Red Clear Ring 1
x	Red Rest Mode Ring 1
y	Spare 4
z	Call to Nonactuated II

TABLE 2
CONNECTOR B
Alphabetical Listing of Pin Assignments

Pin	Function	Pin	Function
A	Phase 1 Next	AA	Overlap A Green Driver
B	Spare 1	BB	Overlap B Yellow Driver
C	Phase 2 Next	CC	Overlap B Red Driver
D	Phase 3 Green Driver	DD	Overlap C Red Driver
E	Phase 3 Yellow Driver	EE	Overlap D Yellow Driver
F	Phase 3 Red Driver	FF	Overlap C Green Driver
G	Phase 4 Red Driver	GG	Overlap B Green Driver
H	Phase 4 Ped Clear Driver	HH	Overlap C Yellow Driver
J	Phase 4 Don't Walk Driver		
K	Phase 4 Check		
L	Phase 4 Veh Call Det		
M	Phase 4 Ped Call Det		
N	Phase 3 Veh Call Det		
P	Phase 3 Ped Call Det		
R	Phase 3 Omit		
S	Phase 2 Omit		
T	Phase 5 Ped Omit		
U	Phase 1 Omit		
V	Ped Recycle Ring 2		
W	Spare 2		
X	Spare 3		
Y	Phase 3 Walk Driver		
Z	Phase 3 Ped Clear Driver		
a	Phase 3 Don't Walk Driver		
b	Phase 4 Green Driver		
c	Phase 4 Yellow Driver		
d	Phase 4 Walk Driver		
e	Phase 4 On		
f	Phase 4 Next		
g	Phase 4 Omit		
h	Phase 4 Hold		
i	Phase 3 Hold		
j	Phase 3 Ped Omit		
k	Phase 6 Ped Omit		
m	Phase 7 Ped Omit		
n	Phase 8 Ped Omit		
p	Overlap A Yellow Driver		
q	Overlap A Red Driver		
r	Phase 3 Check		
s	Phase 3 On		
t	Phase 3 Next		
u	Overlap D Red Driver		

v	Spare 4
w	Overlap D Green Driver
x	Phase 4 Ped Omit
y	Spare 5
z	Max 2 Selection-Ring 2

TABLE 3
CONNECTOR C
Alphabetical Listing of Pin Assignments

Pin	Function	Pin	Function
A	Coded Status Bit A Ring 2	AA	Phase 6 Ped Clear Driver
B	Coded Status Bit B Ring 2	BB	Phase 6 Check
C	Phase 8 Don't Walk Driver	CC	Phase 6 On
D	Phase 8 Red Driver	DD	Phase 6 Next
E	Phase 7 Yellow Driver	EE	Phase 7 Hold
F	Phase 7 Red Driver	FF	Phase 8 Check
G	Phase 6 Red Driver	GG	Phase 8 On
H	Phase 5 Red Driver	HH	Phase 8 Next
J	Phase 5 Yellow Driver	JJ	Phase 7 Walk Driver
K	Phase 5 Ped Clear Driver	KK	Phase 7 Ped Clear Driver
L	Phase 5 Don't Walk Driver	LL	Phase 6 Walk Driver
M	Phase 5 Next	MM	Phase 7 Check
N	Phase 5 On	NN	Phase 7 On
P	Phase 5 Veh Call Det	PP	Phase 7 Next
R	Phase 5 Ped Call Det		
S	Phase 6 Veh Call Det		
T	Phase 6 Ped Call Det		
U	Phase 7 Ped Call Det		
V	Phase 7 Veh Call Det		
W	Phase 8 Ped Call Det		
X	Phase 8 Hold		
Y	Force Off Ring 2		
Z	Stop Timing Ring 2		
a	Inhibit Max Termination Ring 2		
b	Spare 1		
c	Coded Status Bit C Ring 2		
d	Phase 8 Walk Driver		
e	Phase 8 Yellow Driver		
f	Phase 7 Green Driver		
g	Phase 6 Green Driver		
h	Phase 6 Yellow Driver		
i	Phase 5 Green Driver		
j	Phase 5 Walk Driver		
k	Phase 5 Check		
m	Phase 5 Hold		
n	Phase 5 Omit		
p	Phase 6 Hold		
q	Phase 6 Omit		
r	Phase 7 Omit		
s	Phase 8 Omit		
t	Phase 8 Veh Call Det		
u	Red Rest Mode Ring 2		

v Omit All Red Ring 2
w Phase 8 Ped Clear
x Phase 8 Ped Green Clear
y Phase 7 Don't Walk
z Phase 6 Don't Walk

(10) Cabinet Wiring. All cabinet wiring shall be neatly bundled and attached to the sides and back of the cabinet. No stick-on pads will be acceptable. Wiring must be attached to cabinet wall using screws.

Unless otherwise required to accommodate the phase sequence called for on the plans, cabinets shall be wired as follows:

- Four (4) phase cabinets shall be wired for four (4) vehicular phases, 3 pedestrian phases, and 2 overlap phases (set up as the 1+2 and 2+3 overlaps), with the signal monitor programmed accordingly.

- Eight (8) phase cabinets shall be wired for eight (8) vehicular phases and 4 pedestrian phases with the signal monitor programmed accordingly.

(11) Colors of Signals During Flashing Operation. During flashing operation, the colors of the signals shall be as follows unless otherwise called for on the plans:

(i) Single-ring sequences:

- The signals for phase 2 shall flash yellow;

- If phase 1 is a protected-permitted left-turn (i.e., has a 5-section signal head), the circular yellow section in its 5-section head shall flash yellow; otherwise, the signals for phase 1 shall flash red; and

- All other signals shall flash red.

(ii) Dual-ring sequences:

- The signals for phase 2 and 6 shall flash yellow;

- If phase 1 is a protected-permitted left-turn, the circular yellow section in its 5-section head shall flash yellow; otherwise, the signals for phase 1 shall flash red;

- If phase 5 is a protected-permitted left-turn, the circular yellow section in its 5-section head shall flash yellow; otherwise, the signals for phase 5 shall flash red; and

- All other signals shall flash red.

During flashing operation, all signals facing the same approach shall flash concurrently.

A circuit shall be provided and connected to the conflict monitor to cause the signals to flash when a conflict exists.

The flash colors shall be programmed by the Contractor to meet the requirements listed above.

Re-programming shall be accomplishable by adjusting wires on the signal terminal points. This process shall require no tools other than a screwdriver.

(12) Dimensions and Equipment Locations. Dimensions and equipment locations shall be supplied consistent with the following minimum and maximum dimensions and equipment locations:

(i) Top shelf positioned to allow 100 mm above controller to top of cabinet and 100 mm on each side of controller to the sides of the cabinet.

(ii) Second shelf-positioned approximately 200 mm below the top shelf to allow for a 150 mm high amplifier with 50 mm space between top of amplifier and bottom of top shelf.

(iii) Width of cabinet must allow at least 50 mm clearance on each side of the set of amplifiers from the terminal strips mounted on the sides of the cabinet.

(iv) Third shelf (optional) - required if the top and second shelves will not accommodate the conflict monitor, amplifiers and other equipment as required. The third shelf shall allow for the same top and side clearance as on the second shelf.

(v) Load switches - mounted below the bottom shelf at the left rear of the cabinet. With the relays in their bases, a minimum clearance of 50 mm shall be maintained below the bottom shelf and from the terminal blocks mounted on the sides of the cabinet.

(vi) Field connectors - are to be at the bottom rear of the cabinet on horizontal terminal strips. Terminal strip blocks shall be positioned not less than 50 mm nor more than 100 mm from the cabinet bottom.

(vii) Field loop connections are to be made on terminal strips located on the left wall of the cabinet below the bottom shelf.

(viii) Loop amplifier cabinet connections - are to be made on terminal strips on the left wall of the cabinet at the same level as that of the loop amplifier shelf with connections available for AC+, AC-, logic common, and the appropriate input to the controller for each module.

(ix) Cabinet power connections are to be made on the right wall of the cabinet below the bottom shelf and 50 to 100 mm above the bottom of the cabinet.

(x) The maximum outside dimensions of a base-mounted cabinet (exclusive of mounting flanges) shall not exceed 1425 mm in height, 1020 mm in width, and 765 mm in depth.

(13) Switches Inside Main Door.

(i) On/Off power switch: Mounted on the inside of the main cabinet door shall disconnect all equipment in the cabinet from the 120 VAC service line current with the exception of the cabinet light and the duplex convenience receptacle.

(ii) Automatic/Flashing switch: Mounted on the inside of the main cabinet door shall preempt the normal signal display and initiate the specified flashing display. The controller shall continue to operate during this flashing mode.

(14) Police Panel. All cabinets shall be furnished with police compartment extending into the cabinet

shall have all exposed electrical facilities enclosed in a protective housing. The police compartment shall be equipped as follows:

(i) On/Off power switch: Operates same as on/off power switch inside the main door.

(ii) Automatic/Flashing switches: In flashing position, the normal red, yellow, and green signal display shall be preempted for the flashing operation. Upon resuming automatic operation, the controller display shall be in the pre-programmed start-up orientation.

(iii) Normal/Manual switch: When in manual, this switch shall stop the automatic sequence of the controller and hold the existing display until manually advanced into the next interval. When in normal, the automatic control sequence shall continue.

(iv) A miniature panel connector for connecting a detachable hand held push button for manual operation. The connector shall be a Canon #WK-3325 or exact equivalent.

(v) A quality retractile cord with molded hand held push button with attached connector plug for engaging the connector described above. The retractile cord shall be capable of an extension of 2.1 meters minimum and shall be stored in the police compartment when not in use.

(15) Conflict Monitor. Each cabinet shall have a 12-channel conflict monitor which meets the requirements of section 6.06.

(16) Load Switches, Flash Transfer Relays, and Flasher. All load switches shall be three-circuit solid-state load switches conforming to NEMA Section 5. Indicators on the front panel of the load switch shall indicate the status of the input side of the load switch. These switches shall isolate the 24 volt DC signal logic outputs of the controller from the 120 VAC power line and field terminals so as to prevent high energy line transients from entering the controller unit. Each load relay circuit shall optically isolate the field terminal from the controller, shall turn on at zero volts, and be rated at 25 amps output load at 120 VAC. Load switches for vehicular and pedestrian indications shall be interchangeable. Each output shall be driven by a separate controller input, no logic circuitry is permitted in load switches. No reed switches shall be permitted.

Each load switch base shall be identified by phase number and overlap number as applies. Each relay base and power relay base shall be properly identified. No cabinet equipment may obstruct these identifications.

Each cabinet shall be furnished with and wired for a jack-mounted, dual circuit, all solid-state flasher unit. The flasher shall have a duty of 50 percent at a flash rate of 1 Hertz. The flasher shall be wired into the cabinet to provide optionally a yellow/red flash display or an all-red flash display. The flasher shall be rated at 25 amperes per circuit at 120 VAC. Each circuit shall use the same type load cube specified for the signal load switch. A heat sink shall be made a part of the flasher body. Two (2) LEDs shall be incorporated into the flasher to indicate circuit actuation. Load cubes shall be hard-wired to the flasher outputs without the use of printed circuit boards.

Each base-mount cabinet shall be supplied with twelve (12) load-switch sockets, and six (6) flash transfer relays. Each pole-mounted and pedestal-mounted cabinet shall be supplied with eight (8) load-switch sockets, and four (4) flash transfer relays. The number of load switches supplied shall be eight (8) and four (4), respectively, except that a greater number shall be supplied if required to accommodate the phasing called for on the plans.

(17) Detector Amplifiers. Each controller cabinet shall be supplied with harnesses for four-channel

shelf-mounted detector amplifiers which meet the requirements of Subsection 6.07 below. The number of harnesses shall be as follows:

- One (1) or more harnesses to accommodate the number of local detector amplifier channels called for in the plans in the "Summary of Intersection Work, Part 1" plus a minimum of two (2) spare channels.

- One (1) or more harnesses to accommodate the number of system amplifier channels called for in the plans in the "Summary of Intersection Work, Part 1."

(18) Fiber Optic Communications Interface. Except for the test controller cabinets at the Signal Shop, each controller cabinet and each reversible lane controller cabinet shall be supplied with a Fiber Optic Communications Interface which meets the requirements of Subsection 6.08 below.

(19) Miscellaneous Required Facilities.

(i) A minimum of two (2), fully adjustable, metal shelves with brackets to support controller, signal monitor, detector amplifiers and other accessory equipment. The shelves shall be capable of vertical adjustment through virtually the full height of the cabinet.

(ii) Electric service line terminals for 6 gauge copper with 30 ampere circuit protection. Base-mounted cabinets shall have the load split between two (2) 30 amp brakes - one for vehicle signals and one for pedestrian signals.

(iii) 120 Volt duplex convenience receptacle with separate 30 ampere circuit protection.

(iv) Insulated barrier terminals shall be used for detector field connections, AC power supply for amplifiers, and controller inputs from amplifiers. Quantities of terminals shall be supplied for the above connections as follows:

- Four phase controllers - 36 terminal positions; and
- Eight phase controllers - 48 terminal positions.

(v) Grounded neutral buss with multiple screw terminals for 12 gauge copper signal neutrals, and 4 gauge copper earth connections.

(vi) Insulated barrier terminals (2 positions per phase module) for connection of 12 gauge copper signal display field wires.

(vii) Insulated barrier terminals (5 positions per phase module) for connection of 12 gauge copper signal display field wires.

(viii) Insulated barrier terminals for internal wiring interconnect of all other cabinet accessories and circuitry.

(ix) All barrier terminal blocks shall be Cinch Type 150 with numbering strip or equal. This type and size terminal block shall be provided for all applications including controller inputs and outputs, field connections, and detector connections. Terminal pairs shall use a minimum 10-32 size screw and have a minimum center-to-center distance between terminal pairs of 16 mm.

(x) A 120 VAC 20 watt, fluorescent light fixture mounted on the cabinet ceiling at the front of

the cabinet. Fixture shall employ #F20T12/CW20 watt fluorescent tube. An automatic switch shall turn the light on when the main cabinet door is open and turn it off when the door is closed.

(xi) Detector push button switches shall be provided for placing vehicular and pedestrian calls on each individual phase separately. A sufficient number of switches shall be provided to serve the maximum phase capability of the controller unit supplied in case of future expansion. Switches shall be permanently labeled and identified. The switches shall be located such that calls are not inadvertently placed when the cabinet door is closed against control wiring.

(xii) Each cabinet shall have provision for all additional equipment associated with the future expansion to full functional capability including but not limited to load switch bases, complete cabinet wiring, field connection terminals and detector terminals.

(xiii) A clear RE-SEALABLE, plastic envelope shall be attached with screws to the inside of each cabinet door for storage of the cabinet wiring prints. This envelope shall be mounted so as to avoid restriction of the circulation of air into and out of the cabinet.

6.06 Conflict Monitor. A twelve (12) channel conflict monitor which meets or exceeds all requirements of NEMA Section 6 shall be furnished and installed in each new cabinet provided by the Contractor.

Each new conflict monitor shall provide the following features:

(1) Dual Indication Monitoring. This monitoring function shall be required to detect simultaneous indications of active green, yellow, walk and red field signal outputs on the same channel. A dual indication fault shall place the monitor into the fault mode causing the output relay contacts to transfer. Dual indication monitoring shall be enabled concurrently with clearance monitoring on a per channel basis through switches to be supplied on the front panel.

(2) Conflict/Voltage Monitor Operations. One of three different groups of prohibited dual combinations shall be selected via front panel "dual select" switches to be provided on the front panel for all channels which have been enabled for dual indication monitoring.

DUAL SELECT SWITCH (TO BE PROVIDED)

A	B	COMBINATIONS_PROHIBITED_
OFF	OFF	NONE (NO DUAL MONITORING)
OFF	ON	[(G OR W) AND Y]
ON	OFF	[(G OR W OR Y) AND R]
ON	ON	[(G OR W) AND Y] OR [(G OR W OR Y) AND R]

(NOTE: A and B "ON" shall be equivalent to only (G and W) allowed.)

*DUAL INDICATION MONITORING SHALL BE DISABLED WHEN THE RED MONITORING ENABLE INPUT IS REMOVED.

An open or no load condition (i.e., burned out bulb) shall be detected as an active signal due to load switch leakage current and shall cause a dual indication fault. Dual indication monitoring should also anticipate a possible conflict in the event that a proceed signal on a channel is constantly detected as active.

(3) Green-Yellow Dual Indication Monitoring. This monitoring function shall be provided to detect a simultaneous indication of active green and yellow field signal outputs on the same channel. It

will be used to monitor channels which have an unused red field signal output tied to AC+ (i.e., five section signal head) to be enabled by lacing a front panel option switch labeled "green-yellow enable" in the "ON" position. A green-yellow dual indication fault shall place the monitor into the fault mode causing the output relay contacts to transfer. Green-yellow dual indication monitoring should be enabled concurrently with dual indication monitoring. When green-yellow dual indication monitoring is to be enabled, all channels which have not been selected for dual indication monitoring via front panel switches shall be individually monitored for simultaneous indications of active green and yellow field signal outputs. Any channels which have been selected for dual indication monitoring shall function as described above. Green-yellow dual indication monitoring shall be disabled for all channels when the red monitoring enable input is removed.

(4) Clearance (Short or Absent Yellow) Monitoring. This function shall be provided to detect the absence of a minimum 2.8 second period of an active yellow field signal output during a red to green to yellow to red sequence. Clearance monitoring to be enabled concurrently with dual indication monitoring on a per channel basis via front panel switches to be provided.

Clearance monitoring is to be disabled for all channels when the red monitoring enable input is removed.

A clearance (short or absent yellow) fault condition shall place the monitor into the fault mode causing the output relay contacts to transfer. This shall occur when a red input signal to a channel is active following the termination of an active yellow input signal which is less than 2.8 seconds in duration.

(5) Controller Watchdog Monitoring. This function shall be provided to monitor an optional watchdog output from the cabinet controller circuitry. The cabinet controller should toggle the watchdog outputs logic state once every 100 milliseconds. Failure of the monitor to receive a change in state from the controller unit for 1500 milliseconds (±100 milliseconds) shall place the monitor into the fault mode and cause the output relay contacts to transfer. An AC+ brownout condition or a complete loss of AC+ power shall reset the watchdog fault state of the monitor.

NOTE: The watchdog logic input shall be harnessed to a spare pin on the front panel connector.

(6) Walk Disable (Red Monitoring). This option shall be provided to modify the operation of red monitoring. When enabled, the red monitoring function shall not monitor the walk field outputs. Absence of signals on the green, yellow, and red field outputs of a channel shall place the monitor into the fault mode and cause the output relay contacts to transfer.

(7) Non-Volatile Fault Memory. The loss of AC+ power to the monitor shall not reset a fault condition (conflict, dual indication, red failure, clearance, or a voltage monitor latch option is enabled). A BND or controller watchdog fault shall be reset by an AC+ brownout or drop out condition. The monitor shall store the fault and channel indicator status and the time and date the fault occurred into a non-volatile RAM memory device. Should an AC+ power interruption occur while the monitor is in the fault mode, then upon restoration of AC+ power, the output relay shall remain in the fault and the correct fault and channel information shall be displayed. This mode shall be maintained until the monitor receives a reset command from the reset button or the external test reset input.

(8) Real-Time Clock/Calendar. A real-time clock shall be provided in the monitor to identify each fault occurrence with the time of day and date. This information shall be displayed and stored along with the fault status and field output status when the monitor is triggered by a fault condition. The real-time clock shall be backed up by a long life lithium energy cell to maintain

accurate time keeping even during AC+ interruptions. Accuracy should remain within approximately +3 minutes per month. Daylight saving time adjustments are to be made to the time of day on the last Sunday of October and the first Sunday of April. The date and month are to be adjusted for leap years.

Setting the correct time of day and date shall be accomplished using the mode and increment buttons on the front panel.

(9) Fault Data Logging. In addition to displaying the fault status and field output status for a fault condition which may have the monitor unit currently triggered, the monitor shall automatically update and maintain a complete record of the last nine faults which caused the unit to trigger. Reviewing these events shall be accomplished at any time by depressing a "Inc/Prev.Fail" button to be provided on the front panel. This "history" shall be maintained in non-volatile RAM memory and shall not be lost due to AC+ power interruptions.

Faults due to the program card not in place or monitor failures due to internal hardware/firmware problems (monitor fail LED illuminated), are not to be included in the data log.

A controller voltage monitor (CVM) log disable option switch shall be provided on the front panel to disable data logging of CVM failures. This option preserves the fault "history" when the CVM input is used to transfer from normal operation to flashing operation for night time flash or time-of-day flash requirements.

(10) Program Card Readback. In order to verify that the program card information has been properly read by the monitor, the channels programmed as "permissive" on the program card are to be displayed on the field output status display, if desired. This shall be accomplished using the mode and Inc. buttons to be supplied on the front panel.

(11) Program Card Absent. If the program card is absent or not seated properly in the edge connector, the monitor shall enter the fault mode and cause the output relay contacts to transfer. The "program card" indicator on the fault status display shall be displayed to indicate this condition. A manual reset or external test reset shall be required after the program card is properly seated.

(12) Internal Watchdog. The monitor shall generate an internal watchdog pulse from the microprocessor. It shall occur once per line cycle near the start of its program loop. If the internal hardware does not detect a watchdog pulse within 100 milliseconds, the monitor shall enter the fault mode causing the output relay contacts to transfer. A "monitor fail" LED on the front panel shall illuminate to indicate a monitor hardware and/or firmware failure.

(13) Reset Input Detection. This function shall be provided to prevent the cabinet controller from being operated with the monitor disabled due to a faulty reset button or external test reset input. The monitor shall monitor the state of the front panel reset button and the external test reset input. When a reset command is detected from either input, the monitor shall remain in the reset mode with all indicators illuminated, the output and start relays energized, and monitoring functions disabled. If the reset command lasts for a continuous duration of 120 seconds, the monitor shall then automatically enter the normal mode and begin monitoring functions, ignoring the state of the reset inputs.

(14) Voltage Monitor Fault Latch. When the voltage monitor fault option is enabled by the front panel switch to be labeled "VM latch" input, the absence of the proper voltage level at either the CVM input or the two 24 VDC inputs (24V-I & 24V-II) shall place the monitor into the fault mode causing the output relay contacts to transfer. The appropriate fault indicator(s) and the time and date shall be displayed on the fault status display along with the field output signals active at the

time of the voltage fault. Restoration of the voltage levels shall not reset the fault state of the monitor. Only a manual reset or external test reset command shall reset the monitor. IF THE VM LATCH AND CVM LOG DISABLE OPTION SWITCHES ARE BOTH ON, CVM FAILURES SHALL NOT BE LATCHED OR DATA LOGGED.

(15) Display LCD & LED Test. The monitor shall display all front panel LCD indicators and illuminate all front panel LED indicators when a reset command is issued by the front panel reset button or external test reset input. This function shall provide a way to check the operation of all front panel indicators.

(16) Memory Test. The monitor is to verify the proper option of the memory (RAM & EPROM) devices required to operate the monitor. This test shall be performed when AC+ power is applied or a reset command is issued to the monitor. If a monitor will enter the fault mode causing the output relay contacts to transfer, the "monitor fail" LED indicator on the front panel shall illuminate to indicate a monitor hardware and/or firmware failure.

(17) Fault Timing and Configuration Display. The fault timing specifications for conflict, red fail, voltage monitoring, dual indication, clearance fail, and controller watchdog fail (if enabled) as set by the factory shall be reviewed on the fault status display using the Mode and Inc. buttons on the front panel. Timing values for conflict, red fail, voltage monitoring, and dual indication are to be shown in milliseconds. Timing values for clearance fail and controller watchdog fail are to be shown in seconds. Also to be displayed are the channels selected by the switches. If the 24V inhibit input is active, the value displayed for +24V-I and +24V-II shall be shown as "off". Similarly, if red enable is not active the value shown for red fail, dual indication, and clearance fail shall be "off". If both dual select switches and the GY enable switch are off, the value shown for dual indication shall be "off". If the BND monitoring function is disabled the display shall show "off". The "off" display shall indicate that the selected monitor function is disabled.

(18) BND (Blinking/Noise/Dimming) Error Detection. This error detection shall be provided to supplement the unique firmware sampling and digital filtering method for the field input signals which are to provide limited noise immunity. The BND error detection function shall be designed to recognize many of the possible input waveforms and will place the monitor into the fault mode and cause the output relay contact to transfer if the varied and erratic signal conditions exist as described below for a pre-determined period of time. The "BND fail" indicator and the front panel channel indicator(s) on which the fault occurred shall be displayed. An AC+ brownout condition or a complete loss of AC+ power shall test reset the BND fault state of the monitor:

(i) *Blinking*. A signal condition that may exist under certain abnormal circumstances such as: controller output malfunction (i.e., output toggling, pinwheeling, etc.); the output of a load switch intermittently shorting to ground; intermittent field wiring due to corrosion, etc.

(ii) *Noise*. Constant noise on the field output signal that may affect the integrity of the input sample if it occurs exactly within the narrow sampling "window". Depending on the severity and repetition rate of the input noise, a BND error should be detected after the samples have been corrupted for a period of 30 to 200 lines cycles.

(iii) *Dimming*. The sampling and filtering algorithm allows only half wave (positive or negative) suppressed dimming. Other dimming waveforms may be achieved under cabinet controller firmware control and shall be detected as a BND error within approximately 30 periods of the input waveform.

(19) Front Panel Description.

(i) *Field Output Status Display*. The field output status displays shall be liquid crystal displays (LCD). The monitor displays shall exceed the minimum NEMA requirements by showing all four field output signals per channel. When the unit operates normally without a fault condition present, the currently active field output signals shall be displayed. Once triggered by a fault condition, the displays shall retain the signals active at the time of the fault. Dark solid arrows shall be displayed below the channel number for each channel involved in the fault.

(ii) *Fault Status Display*. The main status display shall be a liquid crystal display (LCD). The monitor shall display nine fault conditions in addition to the time and date that the fault occurred. If the unit is operating normally without a fault or voltage monitor condition present, only the current time and date shall be displayed.

(iii) *Voltage Monitor Indicators (CVM/WD, 24V-I, 24V-II)*. One or more of these indicators shall be displayed along with the field output signals active at the time the unit was triggered if the corresponding voltage input is below the minimum specified level. If the voltage monitor latch (VM latch) option is enabled and the unit is triggered by an improper voltage condition, the corresponding indicator(s) shall remain displayed until the unit receives a reset command from the manual reset or external test reset input. If the VM latch and CVM log disable option switches are both enabled (on), CVM failures shall not be latched or data logged. If the controller watchdog monitor option (WD enable) is enabled and the unit is triggered by a controller watchdog output failure, the CVM/WD indicator shall remain displayed until the unit receives a reset command from the manual reset or external test reset input or the AC+ voltage level drops below the specified drop-out level.

(iv) *Conflict Indicator*. A conflict indicator shall be displayed when a conflicting proceed signal fault is detected. The field output status displayed shall show all active field output signals at the time of the conflict. Dark solid arrows shall be displayed below the channel number for each channel involved in the fault.

(v) *Dual Indicator*. A dual indication indicator shall be displayed when a dual indication fault is detected on a channel. The field output status display shall show all active field output signals at the time of the dual indication fault. Dark solid arrows shall be displayed below the channel number for each channel involved in the fault.

(vi) *Red Fail Indicator*. A red fail indicator shall be displayed when an absence of signal (dark signal head) is detected on a channel. The field output status display shall show all active field output signals at the time of the red failure. Dark solid arrows shall be displayed below the channel number for each channel involved in the fault.

(vii) *Clearance Indicator*. A clearance fail indicator shall be displayed when a short (less than 2.8 seconds) yellow signal or absence of yellow signal is detected on a channel(s) during a red to green to yellow to red sequence. The field output status display shall show all active output signals at the time of the clearance fault. Dark solid arrows shall be displayed below the channel number for each channel involved in the fault.

(viii) *BND Indicator*. A BND fail indicator shall be displayed when a blinking/noise/dimming fault is detected on a channel. The field output status display shall show all active field output signals at the time of the BND fault. Dark solid arrows shall be displayed below the channel number for each channel involved in the fault. If the BND fault is detected on the red enable input then no dark arrows should be

displayed.

(ix) *Program Card Indicator*. A program card indicator shall be displayed if the program card is absent or not seated properly in the edge connector. A field output status shall be displayed to show all active field output signals at the time of the fault. A manual reset shall be required after program card is properly seated.

(x) *Previous Failure Indicator*. The monitor shall retain complete information on the last nine consecutive faults which triggered the monitor in addition to the current fault information if the unit has been triggered by a fault condition. The previous fault information should be displayed at any time by depressing a "Inc/Prev.Fail" button, to be provided. The "previous failure" indicator shall be displayed with the number if the fault also shown (previous failure 1 [PF 1] is the most recent failure logged). Each button closure shall display the next previous failure information, returning to the current display on the tenth button closure.

(xi) *Time and Date Display*. A clock and calendar display shall alternate between the time of day and the date. The time shall be denoted by either an "AM" or a "PM" indicator. The date shall be denoted by the "date" indicator. If the monitor is displaying current fault information, then the time and date shall indicate when the fault occurred. If the monitor is displaying previous fault information, then the time and date shall alternate with the previous fault number and indicate when the fault occurred. Otherwise, the current time of day and date shall be displayed.

(xii) *DC Voltage Monitor*.

+24 VDC Inputs (Inactive).....less than +18 VDC
(Active).....greater than +22 VDC

(xiii) *Logic Inputs*

Controller voltage monitor,
Ext. reset, +24V monitor inhibit,
Controller watchdog input
(Active).....less than +8 VDC
(Inactive).....greater than +16 VDC

(xiv) *Timing Functions*

Dual indication
(No Fault).....less than 20 milliseconds
(Fault).....equal to or greater than 2.8 seconds

Watchdog
(No Fault).....less than 1400 milliseconds
(Fault).....greater than 1600 milliseconds
(Typical).....1500 milliseconds

AC+ interruption
(Disable).....greater than 475 milliseconds (+25 milliseconds)

Minimum flash after disable.....4 to 15 seconds (±1 second)

Start delay relay timer.....2.5 seconds (±1 second)

(20) LED Displays.

(i) *Power Indicator*. A power LED indicator is to be provided and to blink at a rate of 2 Hz when the AC+ line voltage goes below the drop-out level (92 VRMS). It shall illuminate steadily when the AC+ line voltage returns above the brown-out restore level (100 VRMS). The indicator shall extinguish when the AC+ line voltage is no longer sufficient to provide the DC voltages necessary for proper monitor operation (approximately 60 VRMS).

(ii) *Fault Indicator*. A fault LED indicator shall illuminate when the unit has been triggered by a fault condition or has sensed a +24V voltage monitor condition and indicates that the monitor has caused the output relay contacts to transfer.

(iii) *Monitor Fail Indicator*. A monitor fail LED indicator shall illuminate when one of the following internal monitor failures are detected: internal watchdog failure, memory test failure, or internal power supply failure. This indicator is to inform the service technician of a monitor hardware and/or firmware failure.

(21) Miscellaneous Requirements.

(i) *Power*.

Operating Line Voltage.....75 to 135 VAC RMS
Operating Line Frequency.....60 ±3 Hz Power
Consumption.....5 W (nominal)
Battery Life Time.....Minimum 8 Years
Minimum Battery Voltage.....2.2 Volts

(ii) *Printer*. The monitor shall be equipped with an infrared printer output to provide a hard copy of the data log and monitor setup. The Contractor shall furnish five (5) compatible printers equal to the Hewlett Packard Model HP 82240A infrared printer. Such printers shall be considered incidental to controllers and cabinets and will not be paid for directly.

6.07 Vehicle Detectors. This subsection defines the minimum acceptable design, operational and functional performance requirements for high performance, multiple channel, inductive loop vehicle detection systems.

(1) General. The detector shall be microprocessor controlled and fully digital, self-tuning. The detector shall be configured as a rack mounted printed circuit board (PCB) for insertion into a NEMA (TS1 or TS2) card rack. Detectors shall also be suitable for use in California/New York TYPE 170/179 or ATC input files.

(2) Ports. Each detector unit shall have two serial ports. A front panel RS-232 port and send/receive pins on the card edge connector. Each port shall be capable of party line communication with up to 8 detectors on the party line.

(3) Interface Software. Interface software shall be provided for use with Windows 3.1 or higher.

This software shall provide an activity screen to display loop system operating characteristics, for each channel, to aid in system setup and diagnostics including:

- Loop Status - Ready, Detect, Fault mode and Reset
- Loop inductance (L) in Microhenries (μH)
- Loop frequency (F) in Kilohertz (kHz)
- Reference frequency (F) in Kilohertz (kHz)
- Maximum Delta inductance (_L) in Nanohenries (nH)
- Green Input Signal (on/off)
- Last Fault (type) - Open, Shorted, ≥25% _L
- When Occurred (Date/Time)
- Detection time in milliseconds (ms)
- Vehicle Count with count Reset button

The activity screen shall include a button to take a snapshot of live data that can be frozen and/or saved to file.

The interface software shall:

- Allow assignment of channel number, loop ID and loop length to enable accurate measurement of vehicle occupancy times. Data shall be available via the serial ports.

- Allow assignment of loop-to-loop distances to enable accurate speed measurement and vehicle length measurement. Data shall be available via the serial ports.

- Provide a vehicle log setup screen and a log screen to report date, time, channel number, loop description, and;

  - ☐ Duration of detection in milliseconds
  - ☐ Loop-to-loop time in milliseconds
  - ☐ Vehicle length in feet or meters
  - ☐ Speed in miles per hour or kilometers per hour.

(4) Miscellaneous Requirements.

- The detector shall include an option to enable a (50 Hz or 60 Hz) filter to insure reliable detection thresholds in power-line-noise environments.

- The Detector shall include optically-isolated, solid-state outputs designed to provide a continuous "fail-safe" (fail-call) output in the event of power loss to the unit.

- The detector shall be available in both two (2) channel and four (4) channel versions.

- Both two (2) and four (4) channel versions shall provide delay and/or extension timing capability of the detection output for each channel, when timing is specified.

- These NEMA detectors shall contain a means to disable the delay and/or extension green sense input circuit on channel four when timing units are installed into a TS2 card rack. This shall allow the wired, 44-pin, edge connector to enable the detector address bit #1 on pin #10.

- Back-plane wiring shall provide four (4) hardwired addresses, to accommodate four 4-channel units, and EIA-232 communication support. The units specified shall be tested for conformity to these requirements, utilizing properly operating loop configurations and

homerun/lead-in combinations described herein. The goal is to obtain detector units that will detect and hold presence of all licensable motor vehicles (including 70 cc motorcycles) when connected to microloop probe sets and/or loop configurations of from 1.8 m x 1.8 m up to 1.8 m x 30 m with lead-ins of from 15 m to over 300 m without detecting vehicles in the adjacent lanes. (Long loops may require special configuration such as the quadrupole configuration to insure adjacent lane rejections.)

- Detector units shall be in full compliance with the environmental, transient and size requirements of NEMA standards TS1, Section 15 and the design, operation, electrical and functional performance requirements of this specification.

- The front panel shall include erasable, write-on pads adjacent to each detect indicator to aid in identification of associated lane, function, or phase activity.

- Each channel shall include two, wide angle, high visibility LED indicators. A green LED to display channel detect output status (output state and also the status of the delay and extension timers) plus a red LED to display loop fault monitor diagnostics (open loop, shorted loop, ≥25% inductance change).

  - ☐ The green detect LED indicators shall repetitively cycle on at:

    -- 4 Hz during Delay timing.
    -- 16 Hz during Extension timing.
    -- During fault detection the green channel detect indicators shall provide a steady indication in either pulse or presence mode.

  - ☐ The red fault LED indicators shall repetitively cycle on for:

    -- One long pulse (1 sec.) and one short pulse (.25 sec.) to indicate open loop.
    -- One long pulse (1 sec.) and two short pulses (.25 sec.) to indicate shorted loop.
    -- One long pulse (1 sec.) and three short pulses (.25 sec.) to indicate ≥25% change of inductance.

- Each channel shall provide a continuous, non-resettable (fail-safe) output and indication in response to an open loop and/or open lead-in system and/or ≥25% _L, except in the OFF mode (when fail-safe operation for a particular fault type is not disabled using the interface software).

- Each channel shall continue to operate with poor quality loop systems ($Q \geq 2$) including those that have a single point short to ground.

- Each channel shall tune to an external inductive load of from 20 up to 2500 microhenries.

- Each channel shall be controlled by a direct reading 16 position push-wheel switch to select a minimum of 8 pulse mode sensitivities, 7 presence mode sensitivities, Channel Reset capability and an Off mode on a per channel basis.

  - ☐ Pulse mode shall be indicated on the push-wheel switch by a pulse symbol over the channel sensitivity numeral.

  - ☐ The OFF position shall be selected by setting "X" on the switch.

- ☐ Selecting OFF shall disable channel output and indicators including fault indications.

- ☐ Pulse mode settings shall provide a single 118 ±2 ms output pulse in response to vehicles entering a loop.

- ☐ If a vehicle remains in the sensing zone the channel shall rephase after 1.9 seconds to enable detecting additional vehicles on unoccupied portions of the loop after 2 seconds. Additionally, the rephase time shall be settable from 0.1 to 25.5 seconds using the interface software.

- ☐ Presence hold times shall be at least 4 minutes for small (70 cc) motorcycles and a minimum of at least 60 minutes for automobiles over 1 to 8, 1.8 m x 1.8 m 3-turn loops connected in series.

- ☐ Special circuitry shall prevent tune-out of continuous peak hour traffic over long or multiple small loops as long as there is vehicle motion into the sensing zone at least every 10 minutes.

- Push-wheel switches shall include 8 sensitivity threshold selections in 2:1 steps over a range of 128:1 to enable precise, predictable selection of the proper sensitivity to detect all licensed motor vehicles.

- The detector shall detect all vehicles over multiple turn loops installed in asphalt or concrete pavement and/or multiple loops that may be connected in series, parallel, or series/parallel, with lead-in/homerun lengths to over 300 meters.

- Detector units shall employ a constant _L threshold that will respond to vehicle generated changes of inductance and provide a relatively constant, predictable response to small licensed motor vehicles without having to change sensitivity selections despite increased series added inductance, i.e., multiple loops connected in series with lead-in/homerun from 15 m to over 300 m.

- Each unit shall contain a common, switched, loop oscillator to eliminate mutual-interference/ magnetic-coupling (crosstalk) from multiple loops in adjacent lanes and/or allow use of overlapped loops for directional control and/or use of multi-conductor homerun cable when connected to the same detector unit.

- Each sensitivity setting shall be equated to nanohenries of inductance change (_L) as shown in Table 6.1.

- Each unit shall contain a frequency switch that will provide three (3) frequency selections per unit to reduce interaction with loops connected to another unit.

- Each unit shall maintain the same sensitivity (threshold in nanohenries) in any of the three (3) frequencies selected.

  - ☐ The maximum response time to an instantaneous beginning or end of a stimulating inductance

Table 6.1
Sensitivity Setting
vs. Inductance Change

Sensitivity Level Setting	Nanohenries _L
C	1024
1	512
2	256
3	128
4	64
5	32
6	16
7	8

change of twice the magnitude required to detect in sensitivity levels 1, 2, and 3, when connected to typical 3 or 4 turn 1.8 m x 1.8 m loops with from 15 m to over 300 m of lead-in/homerun cable attached, shall be less than 3 milliseconds for 2-channel units, and less than 6 milliseconds for a 4-channel unit.

- Each unit shall contain a toggle switch with a spring loaded position that will Reset all channels and stable positions to allow selection of "Normal" or "Fast recovery" mode to enhance performance in left turn lanes or other queue situations.

- Detector units shall automatically self-tune within 4 seconds after application or interruption of supply voltage. Channel outputs shall display calls for a period of less than 4 seconds after which detection shall be normal.

- Each unit shall contain a remote reset input that will allow an external reset of all channels.
  - ☐ When the input voltage on pin C falls below 8 VDC for over 15 microseconds, the detector shall reset all active channels and establish a new reference for each "on" loop within 4 seconds.

- Each channel shall include a DIP switch to invoke a special Microloop mode. Setting this switch shall change the operating mode to be specific to Microloop probes.

- When Delay and/or Extension timing is specified, each channel shall include a 7 position DIP switch on the PCB to select Delay, Extension or Off, if no timing is desired.

  - ☐ Delay time shall be selectable in 0 to 63 seconds in 1.0 second increments.

- ☐ Extension time shall be selectable in 0 to 15.75 seconds in .25 second increments.

- ☐ Selection of OFF shall disable timing in both Pulse and Presence modes.

- When Delay and/or Extension timing is specified, each channel of 2 or 4 channel units shall include an external input to control the timing.

  - ☐ A true condition shall exist if the input voltage falls below 8 VDC for ≥17 microseconds.

  - ☐ Extension timing shall occur only if the corresponding input to the detector channel is true (low/active) and Delay timing shall only occur if the input is false (high/inactive).

- Detector units shall be designed to operate over a voltage range of from 10.8 VDC to 37 VDC.

- Units shall draw less than 50 mA per channel from the DC power source over the input voltage range.

- Each unit shall have a front panel mounted EIA 232 serial communications port to interface with PC's, or other devices.
- Design of the unit shall provide for user selectable changes in operating characteristics, to allow for modification of performance for unique or special applications, that can be obtained by invoking the options from a computer or other device connected to one of the EIA 232 serial interfaces.

- The unit shall record the occurrence of an open loop, shorted loop, or excess inductance change (≥25%).

- The most recent type of error on each channel and the time of error occurrence shall be made available through the serial interface.

- Software command options shall exist to allow the user to:

  - ☐ Choose to eliminate the call output and induction for the open loop condition and other loop problems. It shall not affect the coded flashing fault indicators or software record of failures.

  - ☐ Eliminate the standard 1.9 second pulse rephase altogether, reduce the rephase time to 1.0 seconds or increase rephase time to 3.8 seconds.

  - ☐ Select output Pulse widths of 15 ms., 59 ms., or 236 milliseconds. Standard pulse duration is 118 milliseconds.

  - ☐ Modify minimum (small motorcycle) hold time of 4 minutes (240 seconds) to 7.6 seconds, 120 seconds, or 480 seconds.

  - ☐ Modify standard automobile hold time of typically 1 to 2 hours to .5 to 1 hour, or 2 to 4 hours.

- ☐ Modify background adapt rate from .50 Threshold/second to 0.25, or 1/second.

- The interface software shall aid in the setup of the vehicle detector units by presenting all of the user selectable parameters on the personal computer display, allowing the operator to view and change operating parameters as required. It shall be available on 90 mm-1.44 Mbyte diskette magnetic media. The software shall be compatible and fully operable when used on an Intel-compatible microcomputer with Windows 3.1 or higher.

- The user interface software shall have multiple screens to present all unit setup options, and operating parameters. It shall retrieve and display the unit and loop diagnostics, unit and system measurement values, output status, and it shall download user selectable operating parameters and defaults.

- The Loop Activity (live data) screens shall display the elements shown in Table 6.2.

- The Unit Parameters to be selected or altered shall include those shown in Table 6.3.

- Factory preset defaults shall be stored in memory. User selectable "options" shall be selectable in EEPROM via serial interfaces to modify standard operating parameters.

- In addition the TS2 Address (0-7) and the Reset input line status shall be displayed.

- The Channel Parameters to be selected or altered shall be as shown in Table 6.4.

- The units shall intermate with the 44 pin edge connector shown in Table 6.5.

- Polarization keys shall be located between pins B2 and C3, between pins E5 and F6, and between pins M11 and N12.

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Table 6.2
Loop Activity Screen Displays

Green Input Signal	On/Off
Vehicle Count	Number
Detection Time (Duration)	Milliseconds
Last Loop Fault	Open, Shorted, ≥25% _L
When Occurred	Date and Time
Current Status	Normal or Fault
Call Output	On/Off
Loop Inductance	Microhenries
Loop Frequency	Kilohertz
Reference Frequency	Kilohertz
Max. Delta Inductance Change	Nanohenries
Detect Status	Detect, No detect
Vehicle Count w/Count Reset Button	Count

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Table 6.3
Unit Parameters To Be Displayed or Altered

TS2 Compatible (backpanel addressing)	Enabled/Disabled
Vehicle Count Period	0-63.5 hours (15 min., 1 hr., etc.) or Continuous
Detect Open Loop	Yes, No
Detect Shorted Loop	Yes, No
Detect ≥25% _L	Yes, No
Number of Channels	2, 4
Serial Port Speed	1200, 2400, 4800, 9600 BPS
Fast Recovery Mode	On, Off
Frequency Selection	High, Medium, Low
Configuration Setup Source	Switches, or EEPROM
Power Line Frequency	Disabled, 50 Hz, or 60 Hz
Microloop Filtering	Yes, No
Noise Margin	Low, Medium, High
Rephase Delay	Off, 0.95, 1.8, 4.0, 8.0 Seconds
Output Pulse Width	15, 59, 118, 236 Milliseconds
Washout Delay	7.6, 120, 240, 480 Seconds
Adapt Rate	0, .25, 150, 1.0 Threshold per Second
Reset	Resets Unit and Data

Table 6.4
Channel Parameters To Be Selected or Altered

Sensitivity Threshold Selection	1-8 Settings in 2:1 Increments
Pulse/Presence Mode	Pulse, Presence
Delay Timing	OFF / 1-63 Seconds in 1 second increments
Extension Timing	OFF / 0.25-15.75 Seconds in 0.25 second increments
Microloop Sensors	Yes, No
Long-loop Count	Enabled, Disabled

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Table 6.5
Edge Pin Connector Assignments

Logic (DC) Ground	A	1	Delay/Ext. Ch 1 (DC+input)
DC Supply	B	2	Delay/Ext. Ch 2 (DC+input)
Remote Reset Input	C	3	Delay/Ext. Ch 3 (DC+input)
Loop in Ch 1	D	4	Loop in Ch 1
Loop in Ch 1	E	5	Loop in Ch 1
Ch 1 output (+)	F	6	Detector Address 0
Ch 1 output (-)	H	7	Status output Ch 1
Loop in Ch 2	J	8	Loop in Ch 2
Loop in Ch 2	K	9	Loop in Ch 2
Chassis ground	L	10	Delay/Ext. Ch 4 Det. address 1
AC-neutral	M	11	No connection
AC-line	N	12	No connection
Loop in Ch 3	P	13	Loop in Ch 3
Loop in Ch 3	R	14	Loop in Ch 3
Ch 3 out (+)	S	15	Detector address 2
Ch 3 out (-)	T	16	Status output Ch 3
Loop in Ch 4	U	17	Loop in Ch 4
Loop in Ch 4	V	18	Loop in Ch 4
Ch 2 out (+)	W	19	Data-Transmit
Ch 2 out (-)	X	20	Status output Ch 2
Ch 4 out (+)	Y	21	Data-Receive
Ch 4 out (-)	Z	22	Status output Ch 4

(5) Electrical Connector and Cable

Each amplifier unit shall be furnished with a ten (10) pin M.S. male connector and cable. Terminal wiring shall comply with the following code:

Ten-Pin M.S. 3106B18-1S

Pin	Cable Color Code	Function
C.	Black	115-volt AC line
A.	White	Line Neutral
H.	Green	Earth
B.	Yellow	Relay Common
F.	Blue	Relay N.O. Contact
D.	Gray	Loop
E.	Brown	Loop
G.	Red	Relay N.C. Contact
I.	-----	Not Used
J.	-----	Not Used

Each amplifier unit shall be furnished with a wiring harness with mating M.S. connector. The cable shall be color coded, as above, with insulated spade connectors and shall be minimum 48 inches in length.

(6) Traffic Detector Sensor Units

A. Inductive Traffic Detection Loop in Sawcut.

Inductive traffic detection loops shall consist of conductors embedded in the pavement to measure the inductance of passing vehicles. The loop detector conductors shall consist of wire and tubing with a THNN wire to be inserted into an approved PVC tubing.

WIRE # 14 AWG stranded THNN (UL) 600 V black.
TUBING UL FR-1 rated 150°C
Wall thickness .031"± .003".
Inner diameter nom: .86" min: .182"
max: .198"
Dielectric strength approximately 900 V/MC

The connectors shall be placed in a sawcut which shall be sealed with an approved two-part embedding sealant manufactured specifically for embedding electrical wire or cable in concrete or bituminous pavement to be mixed with sand as recommended by the manufacturer, and meeting the following:

Sp. Gr. A.B./Mix	1.1/0.98/1.04
Viscosity (CPS) @ 77°F A	800
" " " B	1,500
" " " Mix	1,200
Mix Ratio (by volume)	1:1 + 2 Sand
Pot Life (1/2 gal. @ 77°F)	13 minutes
Cure Time @ 77°F	no tackiness after 1 hour
Hardness (Shore D)	60
Tensile Elongation	Greater than 100%
Water Absorption (one day)	0.20%
Salt Walter (3%) Absorption	0.20%
Oil Absorption	0.03%
Gasoline Absorption	1.00%
Volume Resistivity (77°F/150°F)	5.1X1013OHM-CM/2.0X10100HM-CM
Tensile Bond Strength to Concrete @ 77°F	350 psi
Shear Bond Strength to Concrete @ 70°F	1,500 psi

Other sealants manufactured for embedding electrical wire or cable in bituminous or concrete pavement shall not be used unless approved by the Engineer.

B. Pedestrian Push Button Detectors.

The Pedestrian Push Button Assembly for use with the controllers shall be actuated by the pushing of a 2-inch diameter, round, aluminum spring return button which shall cause the closure of a set of internal contacts. The push button / contact assembly shall be screwed into a one-piece, Federal Yellow painted aluminum die cast, cylindrical housing suitable for mounting on a steel pole in conformance with the Plans. The push-button assembly shall be constructed and gasketed to prevent accidental shock and provide weatherproof and freezeproof operation.

6.08 Fiber Optic Communications Interface.

(1) General. Each new controller cabinet (excluding the test cabinets at the Signal Shop) shall have a Fiber Optic Communications Interface. Each such interface shall either be a Type 1 interface or a Type 2 interface, as called for by the application shown on the plans:

(i) At locations where the plans call for only one fiber optic cable with six (6) or fewer fibers to enter a controller cabinet (including locations where the plans call for the installation of a prefabricated drop cable, a Type 1 Fiber Optic Communications Interface shall be provided. (At these locations, no provisions are required in the controller cabinet for splicing of optical fibers.)

(ii) At all other locations, a Type 2 Fiber Optic Communications Interface shall be provided. (At these locations, provisions are required in the controller cabinet to splice optical fibers.)

(2) Type 1 Fiber Optic Communications Interface. Each Type 1 fiber optic communications interface shall consist of one of the following:

(i) A prefabricated (i.e., factory-terminated) MMFO drop cable of sufficient length to extend with adequate slack to the splice cabinet or aerial splice enclosure shown on the plans. Inside of the controller cabinet, a minimum of five (5) meters of coiled slack shall be provided and secured to the cabinet. The incoming drop cable shall be securely tied to the cabinet walls with tie-wraps at intervals of not more than 150 mm between the point where the drop cable enters the cabinet and the coiled slack. Between the coiled slack and the controller, approximately 1.2 meters of length shall be provided for connection to the front panel of the controller. The prefabricated drop cable shall meet the requirements of Subsection 725.09(d).

(ii) A fan-out kit, pre-connectorized with ST-compatible connectors, which shall be used to link the incoming 6-fiber MMFO cable with the controller. The fan-out kit shall provide six (6) one meter lengths of fan-out tubing secured in a modular assembly. The jacket of the incoming cable shall be stripped back and each fiber shall be inserted into a fan-out tube. Each fan-out tube insert shall then be snapped into a protective inner housing. When all inserts have been loaded, an outer housing shall be installed to complete the assembly. The resulting fanned-out fibers shall be connectorized and each shall have a loss which does not exceed 0.3 dB. Each fan-out tube shall provide three levels of protection for the fiber, including a Teflon inner tube, a dielectric strength member, and an outer PVC jacket.

(3) Type 2 Fiber Optic Communications Interface. Each Type 2 fiber optic communications interface shall include the following:

(i) One (1) splice tray housing with front-panel ST-compatible connectors;

(ii) Two (2) or more splice trays; and

(iii) Four (4) prefabricated MMFO patch cables (jumpers) which shall have ST-compatible connectors on each end to connect the front panel of the tray housing with the front panel of the traffic signal controller. Each patch cable shall meet the requirements of Subsection 725.09(e).

(4) Splice Trays. Each splice tray shall be metallic and shall accommodate a minimum of twelve (12) fusion splices plus a minimum of six (6) mechanical splices. The tray shall consist of an aluminum base and an aluminum cover. The design of the tray shall provide physical protection for both types of splices.

Each tray shall have crimpable metal tabs to provide strain relief for the buffer tubes. Additional strain relief points

shall be provided for tie-wrapping buffer tubes or pigtails to the tray. Each tray shall contain organizers which shall hold and protect each type of splice.

The approximate dimensions of each tray shall be 300 mm by 100 mm by 5 mm. A minimum of two (2) trays shall be provided in each housing. Additional trays shall be provided as necessary to accommodate the number of fusion splices required by the initial system construction shown on the plans.

(5) Tray Housing. Each tray housing shall be made of aluminum or stainless steel and shall have the following features:

(i) Accommodation for the number of splice trays required by the initial application called for on the plans plus 25 percent;

(ii) Hinged, lockable door; and

(iii) Front panel with a minimum of twelve (12) ST-compatible connectors. A connector shall be provided for each fiber of each FO cable which is brought into the cabinet The rear of each connector shall have a factory-connected pigtail, which shall be fusion spliced by the Contractor in a splice tray to the incoming or outgoing fibers.

Each splice tray shall slide into the housing and shall securely lock into place. Tray housings may be wall-mounted or rack-mounted at the Contractor's option.

6.09 Shelby County Controller Identification by Type:

(1) Type 2A: Two phase, semi-actuated, solid-state, digitally timed with pedestrian timing for both phases and dual side street maximum.

Type 2B: Two phase, fully actuated, solid-state, digitally timed with pedestrian timing for both phases and dual maximum for each phase.

Type 3A: Three phase, fully actuated, solid-state, digitally timed with pedestrian timing for the artery and the cross street phases and dual maximum for each phase. An advance or leading protected left turn phase is the identifying characteristic of this type.

Type 3T: Three phase, fully actuated, solid-state, digitally timed with pedestrian timing for the artery and the cross street phases and dual maximum for each phase. A trailing or lagging protected left turn phase is the identifying characteristic of this type.

Type 4: Four phase, fully actuated, solid-state, digitally timed with pedestrian timing for the artery and the cross street phases and dual maximum for each phase. The identifying characteristic is a protected left turn phase on one approach of both the artery and the cross street.

Type 5: Five phases, fully actuated, solid-state, digitally timed with pedestrian timing and volume density for two artery and two cross street phases and dual maximum for each of the two left turn phases. The identifying characteristic is a protected left turn phase on both artery approaches with any phase capable of concurrent but independent timing with another non-conflicting phase.

Type 6: Six phase, fully actuated solid-state, digitally timed with pedestrian timing and volume density for two artery and two cross street phases and dual maximum for each of three left turn phases. The identifying characteristic is a protected left turn phase on one cross street approach and a protected left turn on both artery approaches with any phase capable of concurrent but independent timing with another non-conflicting phase.

Type 8: Eight phase, fully actuated, solid-state, digitally timed with pedestrian timing and pedestrian timing and volume density for two artery and two cross street phases and dual maximum for each of four left turn phases. The identifying characteristic is a protected left turn phase on both artery approaches and both cross street approaches with any phase capable of concurrent but independent timing with another non-conflicting phase.

SECTION 7. SIGNAL HEAD

7.01 General:

(1) This specification describes the minimum requirements for traffic signal heads and pedestrian signal heads and mounting hardware.

(2) Signal Heads.

Vehicle and pedestrian signals complete with mounting devices as shown on the Plans and Design Standards shall be provided by the Contractor. Each signal face shall consist of one or more signal sections, designed and constructed so as to fit rigidly and securely together, one above the other to present a clean appearance and provide a weathertight enclosure for the optical and electrical equipment. These signal heads shall meet the requirements of the latest ITE Standards for "Adjustable Face Vehicle Traffic Control Signal Heads," the "Adjustable Face Pedestrian Signal Head Standard", and the NEC where applicable. Each signal head assembly shall be supplied complete with a traffic signal illuminating device of the required size and ready for operation with the connection of field wiring.

A. Materials.

The housing and door of each signal section shall be fabricated from corrosion-resistant U.V. stabilized Polycarbonate resin material. The moldings shall be a minimum of 0.090 inches thick and be ribbed for additional strength at point of high stress. Additional thickness shall be provided as necessary to eliminate light transmission through the housing, door, visor, or backplate.

Visors and backplates shall be fabricated from corrosion resistant U.V. stabilized Polycarbonate resin material. Visors shall have a 0.100-inch minimum thickness. Backplates shall have a 0.125-inch minimum thickness.

7.02 Housing:

(1) The housing of each section shall be a one-piece, corrosionresistant, Polycarbonate resin molding with integral blow holes. Each vehicle signal shall be furnished with provisions for mounting of a backplate. The top and bottom of the housing shall have an opening 2 inches in diameter to accommodate standard 1/2-inch pipe, with no other opening in the top or bottom of the housing. Individual signal sections shall be fastened together, one above the other into a complete signal face, by means of plated nuts, bolts, and washers in such a manner that any section may be rotated about a vertical axis and positioned at an angle with respect to an adjacent section. The opening hub shall have 72 circumferential serrations to secure each section in its orientation adjustable in 5-degree increments, and prevent its inadvertent rotation. A six-position labeled barrier terminal block shall be provided in each signal face for the purpose of field connections. The barrier terminal shall be installed in the circular yellow or yellow arrow section of each signal face. If the face has neither of these sections, the terminal block shall be installed in the uppermost section of the head. There shall be provisions for the attachment of a 1/4 inch tether line to the bottom of each span wire-mounted signal head as shown in the Design Standards. A pinnacle shall be provided to close all 2-inch openings in each housing which will not otherwise be sealed from the weather when installed with the specific mounting hardware.

(2) The housing door of each signal section shall be a one-piece, corrosion-resistant Polycarbonate resin molding free of voids, cracks, inclusions, or blow holes. The outer face of the door shall have four (4) holes equally spaced about the circumference of the lens opening to accommodate the secure mounting of the signal head visor. Two stainless-steel hinge pins shall attach the door to the housing, one in the upper left corner and one in the lower left corner of the door. Two stainless-steel wing nuts or screws, one in the upper right corner and one in the lower right corner of the door, shall be used for opening the door and closing it tight against the housing. The wing screws or nuts shall be installed to prevent their accidental removal or falling out. The removal of the hinge pins and the operation of the wing nuts or screws shall not require the use of tools.

(3) Mounting Hardware.

Spanwire suspension fitting with cable entrance shall be one-piece malleable iron casting, minimum wall thickness 3/16 inch, and free of flash and voids. The cable entrance shall have a plastic bushing with a minimum inside diameter of 1-1/4 inches. The suspension fitting shall provide six separate, clevis pin positions for balancing the signal assembly. The thickness of the solid casting in this suspension area shall be a minimum of 5/8 inch. A hex head threaded malleable iron lock nipple shall be provided for attaching the signal head to the bottom of the suspension fitting for one-face signals or to the top bracket of multiface signal brackets.

The mounting hardware for each signal face shall include a nylon, serrated, 72-tooth lock ring with full locking pins and a circular neoprene gasket for weather sealing.

All openings in signal heads and bracketry which are not otherwise utilized for a signal mounting shall be closed with a hex ornamental pinnacle assemble complete with circular neoprene gasket and malleable iron hex lock nut. No conduit lock nuts are permitted.

The Spanwire Suspension Clamp Assembly, where required, shall consist of a galvanized, malleable iron spanwire clevis saddle, 5/8 inch diameter plated steel clevis pin with cotter key, two 1/2 inch plated steel "U" bolts with nuts and washers (no "J" bolts are permitted), and a galvanized malleable iron cable locking bar - all fitted for 5/15 inch guy span. Galvanizing shall conform to ASTM A 153.

The Balance Adjustor required for each spanwire suspended signal head shall be supplied with a malleable iron balance adjustor complete with steel I-bolt and steel clevis pin with cotter key to be installed between the spanwire suspension clamp and the suspension fitting with cable entrance.

Brackets, where required, shall consist of a malleable iron center outlet body, schedule 40 pipe, elbows, serrated fittings, and other hardware as required to provide a multiface signal head assembly with internal wiring raceways to each face as specified.

The Spanwire Bottom Bracket, where required, shall consist of 2-5/8" x 1/8" steel brace with an arm fitted with a pinnacle, noeprene washer, and malleable iron hex lock nut for each signal face to be accommodated (conduit lock nuts are not acceptable). An attachment fitting for 1/4 inch tether wire shall be mounted at the center of the bracket as shown in the Design Standards.

The Polycarbonate Side of Pole Bracket, where required, shall be one-piece molding with internal wiring raceway for banding or lag screw attachment to steel or wood poles. Brackets shall be designed to withstand 100 mph wind loading on it and the signal head. Each bracket shall have an integrally molded 72-tooth serrated ring for signal head positioning and come complete with 1-1/2 inch nipple, hex lock nut, pinnacle, neoprene washer, and one 1/4 inch interlock shim for plumbing signals.

The Elevator Plumbizer, where required, shall be malleable iron or bronze alloy for mast arm installations, with internal wire raceway, sized to fit a 1-1/2 tennon, complete with three screws and one through bolt with nuts and lock washer, complete with serrations to lock signal position - to be installed between the red and yellow sections.

The Slip Fitter Collar, where required, for top post mounting shall be malleable iron, including one vertical 1-1/2 inch nipple with hex lock nut: two 1-1/2 inch threaded horizontal entrances; and three set screws for attachment to the post. All horizontal entrances not used for attaching signal brackets shall be closed with pinnacle and neoprene washer.

7.03 Optical System

1. Displays – All signal displays shall be of the LED-type meeting the requirements set forth in Section 11.

2. Visors - Each signal shall be fitted with a corrosion-resistant Polycarbonate resin tunnel visor. Eight-inch signals shall have visors a minimum of 7 inches long; 12-inch signals shall have visors a minimum of 9-1/2 inches long. The visors shall be flat black inside and outside. The visors shall be securely attached to the door at four locations equally spaced about the circumference of the lens opening with four plated screws or four bayonet-type self locking tabs integrally formed with the visor. The visor shall fit flush against the door, and no light shall leak between the door and the visor. The visor shall be preformed into a fixed cylindrical shape of the proper diameter to be installed around the lens.

3. Backplate. - Each vehicle signal head assembly, so required by the Plans, shall be equipped with a backplate with a minimum width of 5 inches with rounded corners. Stainless-steel screws shall be provided for mounting to the signal housing. The backplate shall consist of one or more pieces fabricated from corrosion-resistant, flat Polycarbonate resin material colored flat black on the front and back.

7.04 Color, Finish, and Painting.

Polycarbonate resin hardware shall have color impregnated throughout the material. The finish shall be smooth and unflawed. Signal head parts shall be colored as follows:

1. Vehicle Head:

   Housing - Federal Yellow
   Door - Flat Black
   Tunnel Visor - Flat Black inside and out
   Backplate - Flat Black front and back
   Pole Bracket - Federal Yellow

2. Pedestrian Head:

   Housing -Federal Yellow
   Door - Black
   Tunnel Visor - Flat Black inside and out
   Pole Bracket - Federal Yellow

All metal hardware, except those specified as galvanized, plated, or stainless steel shall be painted Federal Yellow. The metal parts shall be painted with a primer coat and a finish coat of oven-baked enamel meeting the requirements of this Specification. Lenses, reflectors, gaskets, and Polycarbonate parts shall not be painted.

7.05 Until such time as the Department has made final acceptance, fixture heads shall remain concealed from view of approaching traffic by means of heavy, opaque plastic or canvas cloths, draped over and securely attached to heads.

SECTION 8. VIDEO DETECTION SYSTEM AND PEDESTRIAN DETECTION

8.01 General

(1) Vehicular traffic detection shall utilize video detection technology at all locations unless otherwise noted in the Plans.

(2) Contractor shall provide video detection system that meets all specifications for the Iteris Vantage video detection system.

8.02 Materials and Equipment

The Contractor shall provide all equipment and materials to provide for a fully-functional video detection system, including the following:

(1) A video processing unit capable of accommodating all cameras located at the intersection.

(2) All cameras as indicated in the Plans.

(3) Camera mounts, including arms, brackets, fittings, and other items needed to properly secure camera to poles or mast-arms.

(4) A grayscale ("black & white") video monitor having a 12" minimum nominal diagonal screen size. Monitor shall have external power switch and controls for horizontal and vertical hold, brightness, and contrast.

(5) A two-button mouse with mousepad for use in setting detection zones.

(6) All cables needed to properly power the system and deliver the camera feed to the video processing unit and detection calls to the signal controller.

8.03 Pedestrian Push Button Detectors

The Pedestrian Push Button Assembly for use with the controllers shall be actuated by the pushing of a 2-inch diameter, round, aluminum spring return button which shall cause the closure of a set of internal contacts. The push button / contact assembly shall be screwed into a one-piece, Federal Yellow painted aluminum die cast, cylindrical housing suitable for mounting on a steel pole in conformance with the Plans. The push-button assembly shall be constructed and gasketed to prevent accidental shock and provide weatherproof and freezeproof operation

SECTION 9. PULL BOXES

9.01 General:

Pull boxes shall be installed at locations shown on plans or where directed by the Engineer. Additional pull boxes may be required where conduit runs are more than 150 feet long. Covers shall be flush with the curb or sidewalk grade or with the surrounding ground as required. No pull boxes shall be placed in the roadway area.

9.02 Materials:

A. Traffic Pull Boxes

1. Pull boxes shall be constructed of concrete (5000) psi) reinforced in accordance with the details as shown in the Plan. Reinforcement shall consist of steel wire fabric, 4" x 4" - No. 4/4 @ 85 lb./100 square feet, meeting the requirements of Article 907.03 of the Tennessee Standard Specifications for Road and Bridge Construction.

2. The cover shall have roughened top surface. Notches shall be provided for removing the cover. The words "Traffic Signal" shall be inscribed on top of the cover with letters 2 inches high and 1/8 inch in relief as indicated on the Plans.

B. Fiber Optic Pull Boxes

1. Pull boxes shall be Quazite™ brand or approved equipment, provided in the sizes indicated in the plans. The cover shall have roughened surface with the words "TRAFFIC SIGNAL" inscribed on the top of the cover. The cover shall be secured to the body of the box with bolts.

9.03 Installation:

1. Pre-cast pull boxes shall be shipped to the job site only after approval is obtained from the Engineer.

2. The excavation shall be maintained as closely as possible to the prescribed size of the box.

3. Fill material for drainage shall be coarse aggregate, as defined by Section 710.05 and 903.7 of the Tennessee Standard Specifications for Road and Bridge Construction. The box shall be set level, and the exposed surface shall conform to surrounding grade. Area around pull boxes shall be cleared of all excess dirt, lumber, asphalt, concrete, etc., following installation and acceptance of pull boxes. Pull boxes shall be installed with their longer side parallel to the adjacent curb line.

4. The bottom of the pull box shall be set firmly on a bed of crushed stone with a minimum depth of 12 inches below the bottom and extending 6 inches beyond the outside edge of the pull box, unless otherwise specified by the Engineer.

5. Electrical conductors shall be placed within pull boxes in such a manner as to be clear of any metal frame and the cover.

6. Ground rods shall be placed in the pull boxes where required in accordance with the plans and design standards.

SECTION 10. SIGN AND SIGNAL SUPPORTS, AND POLE FOUNDATIONS

10.1 General:

1. These Specifications apply to poles for the support of traffic signals and signs to be used in Shelby County. The height of poles, shaft dimensions, and wall thickness shall meet the design requirements and mounting height of traffic signals and signs as set forth in these Specifications and on the Plans.

2. The pole shall be fabricated from best, hot-rolled basic open hearth steel and shall have only one longitudinal electrically welded joint and no intermediate horizontal welds or joints. The shaft shall be longitudinally cold-rolled to flatten the weld and increase the physical characteristics so that the metal will have a minimum yield strength of 55,000 psi.

3. The steel poles covered under these specifications shall be tapered, upright circular steel with a uniformly tapered shaft and a round cross section. These poles shall be processed to a minimum yield stress of 55,000 psi. The pole wall thickness (gauge) and other specification data in Table 9 and elsewhere in this specification shall relate to the characteristics of the completed pole after fabrication. Steel sign and signal poles shall have a section modulus equal to or exceeding those in Table 9.

4. The materials used shall meet or exceed the standards of American Society of Testing and Materials and the Society of Automotive Engineers, as noted, and such standards shall be made a part of this specification. Poles shall be galvanized inside and outside to ASTM A-123.

5. All welding shall be performed by welders qualified in accordance with "American Welding Society Standard Specifications for Welded Highway and Railway Bridges." All welding shall be performed in the positions using the electrodes and procedures permitted under the qualification techniques.

6. All steel and cast iron components, hardware and threaded fasteners, except anchor bolts, shall be galvanized after fabrication in accordance with ASTM Designations A-123, A-153 or A-385, as applicable.

TABLE 9

MINIMUM SECTION MODULUS FOR STEEL POLES

(Inches)

	12-Inch Base Diameter			13-Inch Base Diameter		
Location	#0 Gauge	#3 Gauge	#7 Gauge	#0 Gauge	#3 Gauge	#7 Gauge
Base	32.6	26.5	19.3	38.5	31.3	22.8
20'	29.3	15.3	11.2	23.2	18.9	13.8
24'	16.4	13.4	9.8	20.6	16.8	12.3
28'	14.2	11.6	8.5	18.2	14.8	10.9

30'	.13.2	10.8	7.9	17.0	13.9	10.2
32'	12.2	10.0	7.4	15.9	13.0	9.6

10.2 Strain Poles:

(1) Strain poles shall be galvanized steel with a uniformly tapered shaft. All poles shall be complete with a removable cast aluminum top cover with stainless steel set screws for fastening cover to top of pole. A "J" hook wire support shall be located inside the pole near the top, and four 2-inch threaded pipe couplings shall be located on the outside near the top of the pole. Two "U" bolt spanwire clamps shall be furnished complete for each pole. The threaded bolt shall be 5/8-inch in diameter and shall be furnished with galvanized hexagon nuts. The clamps shall be sized to fit each tapered pole at a point 18 inches from the top. A 4-inch by 8-inch curved handhole with 11-gauge galvanized steel cover shall be installed 18 inches above the base of anchor base poles. The handhole opening in the pole shall be fitted with a steel frame welded into place. The cover shall be furnished with two (2) 1/4-inch stainless steel installation screws and a No. 35 stainless steel chain to leash the cover at the handhole. The handhole shall be oriented on the pole so that it is centered between two adjacent anchor bolt holes in the base. A ground lug for No. 6 AWG ground wire shall be provided inside each pole and accessible from the handhole. The pole and all of its component parts shall be designed to support traffic signals or signs of the type and number indicated on the plans, suspended from a spanwire assembly. The shaft shall be fabricated from material providing a minimum yield strength of 55,000 psi after fabrication.

(2) Unless otherwise specified, all strain pole traffic signal or sign supports shall be anchor base poles designed for installation on concrete foundations. The base shall be fabricated from drop-forged or cast steel of sufficient cross section to fully develop the ultimate strength of the poles. The base shall be fastened to the pole by means of a welded connection and shall develop full strength of the pole. The base shall be provided with four holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting (at yield stress) the bending moment of the shaft at its yield strength stress. Four removable cast iron covers for the anchor bolts shall be provided with stainless steel attaching screws.

(3) The pole and all of its component parts shall be designed to support traffic signals or signs of the type and number indicated on the Plans, suspended from a spanwire assembly. The shaft shall be fabricated from material providing a minimum yield strength of 55,000 psi after fabrication.

(4) Plumbing of standards, posts, and pedestals shall be accomplished by adjusting the nuts. Shims or similar devices for plumbing or raking will not be permitted. After plumbing or raking has been completed, anchor bolts will be cut off 1/4 inch above the top nut and the exposed surface painted with rust protective paint. Caps shall be placed over the nuts and a cement grout placed under the pole with a weep hole - all as shown in the Plans.

10.3 Foundations:

(1) Foundations for posts, standards, and pedestals shall be Class A portland cement concrete per Special Provisions herein. Anchor bolts, conduits, and reinforcing steel shall be placed in accordance with the Plans and design standards.

(2) Foundations for posts, standards, and pedestals shall be poured monolithically to final grade. The exposed portions shall be formed and finished to present a neat appearance. The bottom of concrete foundations shall rest on firm, undisturbed ground. A vibrator shall be used in the pouring of all foundations to remove voids and air entrapment.

(3) Forms shall be true to line and grade. Tops of foundations for posts and standards, except special foundations, shall be finished at sidewalk grade or as ordered by the Engineer. The tops of foundations shall be 6 inches deep and square, with the dimension equal to the diameter of the foundation. A 1-inch joint material shall be placed around the 6-inch top square. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed in proper position and to proper height and shall be held in place by means of a template until the concrete sets. Calcium chloride may not be used to speed the setting of the concrete. Conduit entries in addition to those required for installation shall be placed in each foundation, oriented as shown on the plans or as directed by the Engineer, and capped according to these Specifications.

(4) Both forms and ground that will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has thoroughly cured for at least 12 hours and hardened sufficiently to allow form to be removed with causing damage to the concrete. No pole shall be installed until eight (8) days after the foundation has been poured.

(5) Ordinary surface finish shall be applied to exposed surfaces of concrete. Wherever the edge of a concrete foundation or sidewalk section is within 18 inches of any existing concrete improvement, the sidewalk section shall be extended to meet said existing improvements.

(6) Where obstructions prevent construction of planned foundations, the Contractor shall construct a foundation satisfactory to the Engineer.

10.4 Anchor Bolts:

(1) High strength steel anchor bolts, each fitted with one regular hex nut and one heavy duty square nut, shall be furnished with anchor-base type of poles. All nuts and not less than 10 inches of the threaded ends of anchor bolts shall be hot-dipped galvanized in accordance with ASTM Designation A153. The anchor bolts shall have a minimum yield strength of 55,000 p.s.i. and a minimum ultimate strength of 90,000 p.s.i. each. The anchor bolts shall be capable of resisting (at yield strength stress) the bending moment of the shaft at its yield strength stress.

(2) Anchor bolts and nuts required for relocating existing standards and posts shall be furnished by the Contractor.

10.5 Mill Test Reports and Certification:

Mill Test Reports and Certifications of Specifications for Materials and Design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the materials:

a. "Mill Test Reports" (M.T.R.) for MAJOR structural items only, as noted in Table 2701-10, shall include both physical and chemical descriptions of the materials as supplied to the fabricator. When physical properties are altered during the fabrication, M.T.R. covering chemical composition will be supplemented by certified test reports indicating the physical properties of this material after fabrication.

b. Certification of conformance to the Specifications for all remaining material not covered by M.T.R. as noted in Table 10.

c. Certification that all welding was performed by operators qualified as follows: Steel welders to AWS and aluminum welders to ASME.

d. Certification of conformance to Specification for the design of all components not completely dimensioned and detailed in the Design Standards.

TABLE 10

MILL TEST REPORT AND CERTIFICATION OF CONFORMANCE REQUIREMENTS

Component Materials	M.T.R.	Certification
Tubes for arms and poles	X	
Base castings	X	
Anchor Bolts	X	
Pole tops miscellaneous fittings and hardware		X
Fabricated or cast type arm connections		X
Galvanizing		X
Signal cable and wire		X
Loop Sealant		X
Concrete	X	

SECTION 11. LIGHT EMITTING DIODE (LED) MODULES

11.01. TRAFFIC SIGNAL

(1) PURPOSE - This specification provides the minimum performance requirements for 300 mm (12 in) and 200 mm (8 in) LED traffic signal modules. It is not intended to impose restrictions upon specific designs and materials that conform to the purpose and the intent of this specification. This specification refers to definitions and practices described in "Vehicle Traffic Control Signal Heads" published in the *Equipment and Materials Standards of the Institute of Transportation Engineers*, referred to in this document as "VTCSH". The multiple LED light source should be the latest technology available on the market. The LEDs utilized shall be AlInGaP technology for red, and yellow indications, or InGaN technology for green indications. LEDs shall be the ultra bright type rated for 100,000 hours of continuous operation from -40C to +74C.

(2) PHYSICAL AND MECHANCIAL REQUIREMENTS

2.1 LED Signal Module

2.2.1 Tinting - The lens shall be tinted or colored to match the wavelength (chromaticity) of the LED as long as the luminous intensity still conforms to ITE table 1.

2.2.2 The LED module shall be constructed to allow the replacement of the outer lens and/or the light engine as needed.

2.2 Environmental Requirements

2.2.1 The LED module shall be rated for use in the ambient operating temperature range of -40°C (-40°F) to +74°C (+165°F).

2.2.2 The LED module shall be protected against dust and moisture intrusion as per NEMA Standard 250-1991 requirements, for Type 4 enclosures to protect all internal LED, electronic, and electrical components.

2.2.3 The LED signal module lens shall be UV stabilized.

2.2.4 The lens shall be smooth on the outside to prevent excessive dirt/dust buildup, and be specifically designed to reduce sun reflections (Sun Phantom).

2.2.5 The LED module must be supplied with an installed gasket.

2.3 Construction

2.3.1 The LED module shall be a single, self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing. The power supply must fit and mount inside the LED module.

2.3.2 The assembly and manufacturing process for the LED assembly shall be designed to assure all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

2.4 Materials

2.4.1 Materials used for the lens and LED module construction shall conform to ASTM specifications where applicable.

2.4.2 Enclosures containing the power supply and electronic components of the LED module shall be made of UL94VO flame retardant materials. The lens of the LED module is excluded from this

requirement.

2.5 Module Identification

2.5.1 Each LED module shall be identified on the backside with the manufacturer's name and serial number.

2.5.2 The following operating characteristics shall be identified: nominal operating voltage, power consumption, and Volt-Ampere.

2.5.3 LED modules shall have a prominent and permanent vertical indexing indicator, i.e., UP ARROW or the word UP or TOP, for correct indexing and orientation inside a signal housing.

(3) PHOTOMETRIC REQUIREMENTS

3.1 Luminous Intensity & Distribution

3.1.1 The maintained minimum luminous intensity values for red, yellow, and green LED modules throughout the warranty period, under the operating conditions defined in Sections 2.3.1, 4.2.1 and 5.4.2, and at the end of the warranty period, shall not be less than the values shown in Table 1 & 2, and are required to meet initial luminous values that are 115 percent of the required minimum values in the specification (Table 1 & Table 2).

3.1.2 When operating within the temperature range specified in Section 2.3.1 during the warranty period, the maximum luminous intensity for the 8-inch or 12-inch signals shall not exceed 800 candelas for the Red, 1,600 candelas for the Green, and 1,600 candelas for the Yellow.

3.1.3 The optical lens should reflect a light distribution look similar to that of an incandescent lamp with expanded view for special applications. To ensure even illumination 12" LED full ball modules shall consist of a minimum of 100 InGaN (green) or AlInGaP (red and amber) LEDs.

3.1.4 The LED arrow module shall have a full, filled profile, reflecting a light distribution look and appearance similar to that of an incandescent lamp, without the individual LED's being visible. The arrows shall meet all Caltrans specifications on light intensity.

3.2 Chromaticity - The measured chromaticity coordinates of LED modules shall be between 500 nm and 650 nm, conforming to the chromaticity requirements of Section 8.04 and Figure 1 of the VTCSH standard.

Table 1. Maintained Minimum Luminous Intensity for 12" Expanded View LED Signal Modules Candlepower Values (candelas (cd))

Vertical Angle	Horizontal Angle (Left & right)	12-inch Signal		
		Red	Yellow	Green
17.5 up	17.5°	3	7	7
	2.5 °	10	20	20
12.5 up	17.5°	14	27	27
	2.5 °	20	41	41
7.5 up	17.5°	20	41	41
	2.5 °	54	108	108
2.5 up	17.5°	58	115	115
	2.5 °	220	441	441
-2.5 down	2.5°	339	678	678
	7.5 °	251	501	501
	12.5 °	141	283	283
	17.5 °	77	154	154
-7.5 down	2.5 °	226	452	452
	7.5 °	202	404	404
	12.5 °	145	291	291
	17.5 °	89	178	178
	22.5 °	38	77	77
	27.5 °	16	32	32
-12.5 down	2.5 °	50	101	101
	7.5 °	48	97	97
	12.5 °	44	89	89
	17.5 °	34	69	69
	22.5 °	22	44	44
	27.5 °	16	32	32
-17.5 down	2.5 °	22	44	44
	7.5 °	22	44	44
	12.5 °	22	44	44
	17.5 °	22	44	44
	22.5 °	20	41	41
	27.5 °	16	32	32
-22.5 down	2.5 °	10	20	20
	7.5 °	7	14	14

Table 2. Maintained Minimum Luminous Intensity for 8-inch LED Signal Modules Candlepower Values (candelas (cd))

Vertical Angle Down	Horiz. Angle Left & Right	8-inch Signal		
		Red	Yellow	Green
2.5°	2.5°	133	267	267
	7.5°	97	194	194
	12.5°	57	113	113
	17.5°	25	48	48
7.5°	2.5°	101	202	202
	7.5°	89	178	178
	12.5°	65	129	129
	17.5°	41	81	81
	22.5°	18	37	37
	27.5°	10	20	20
12.5°	2.5°	37	73	73
	7.5°	32	65	65
	12.5°	28	57	57
	17.5°	20	41	41
	22.5°	12	25	25
	27.5°	9	16	16
17.5°	2.5°	16	32	32
	7.5°	14	28	28
	12.5°	10	20	20
	17.5°	9	16	16
	22.5°	6	12	12
	27.5°	4	9	9

(4) ELECTRICAL

4.1 General - All wiring and terminal blocks shall meet the requirements of Section 13.02 of the VTCSH Standard. Two secured, color coded, 914 mm (36 in) long 600 V, 20 AWG minimum, jacketed wires, conforming to the National Electrical Code, rated for service at +105°C, are to be provided for electrical connection.

4.2 Voltage Range

4.2.1 LED modules shall operate from a 60 ± 3 cycle ac line power over a voltage range from 80 Vac rms to 135Vac rms. The current draw shall be sufficient to ensure compatibility and proper triggering and operation of load current switches and conflict monitors in the signal controller that the procuring traffic authority customer has in use.

4.2.2 Nominal operating voltage for all measurements shall be 120 ± 3 Volts rms.

4.2.3 Fluctuations in line voltage over the range of 80Vac to 135Vac shall not affect luminous intensity by more than ± 10 percent.

4.2.4 The LED circuitry shall prevent flickering at less than 100 Hz over the voltage range specified in Section 4.2.1.

4.2.5 Low Voltage Turn Off - There shall be no illumination from the module when the applied voltage is less than 45 volts AC. To test for this condition the unit must first be fully illuminated at the nominal operating voltage. The applied voltage is then reduced to the point that there is no illumination. This point must be greater than 45 volts AC. The same requirement should apply in rising voltage from 0 to 45 with no visible illumination.

4.2.6 Turn-On and Turn-Off Time:
The modules shall reach 90% of their full illumination (turn-on) within 100 msec (+ or - 10%) after the application of the nominal operating voltage. The LED modules shall not be illuminated (turn-off) within 100 msec (+ or - 10%) after the removal of the nominal operating voltage.

4.3 Transient Voltage Protection

4.3.1 The LED module on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients and low-repetition, high-energy transients as stated in Section 2.1.6, NEMA Standard TS-2, 1992.

4.4 LED Drive Circuitry

4.4.1 The individual LED light sources shall be wired so that the catastrophic failure of one LED will result in the loss of the light from only that one LED.

4.4.2 The power supply must be current regulated.

4.5 Electronic Noise - The LED module and the associated on-board circuitry must meet Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.

4.6 Power Factor and AC Harmonics

4.6.1 LED modules shall provide a power factor of 0.90 or greater when operated at nominal operating voltage, and 25°C (77°F).

4.6.2 Total harmonic distortion induced into an ac power line by an LED signal module, operated at nominal operating voltage, at 25°C (77°F) shall not exceed 20 percent.

(5) QUALITY ASSURANCE

5.1 General

5.1.1 Quality Assurance Program - LED modules shall be manufactured in accordance with a vendor quality assurance (QA) program. The QA program shall include two types of quality assurance: (1) design quality assurance, and (2) production quality assurance. The production quality assurance shall include statistically controlled routine tests to ensure minimum performance levels of LED modules built to meet this specification.

5.1.2 Record Keeping - QA process and test result documentation shall be kept on file for a minimum period of seven years.

5.1.3 Conformance - LED module designs not satisfying design qualification testing and the production quality assurance testing performance requirements in Sections 5.3 and 5.4 shall not be labeled, advertised, or sold as conforming to this specification.

5.2 Manufacturers' Serial Numbers - Each LED module shall be identified by a manufacturer's serial number for warranty purposes.

5.3 Production Quality Assurance (QA) Testing - All new LED modules shall undergo the following Production Quality Assurance testing prior to shipment. Failure of any LED module to meet requirements of these QA tests shall be cause for rejection. QA test results shall be maintained per the requirement of Section 5.1.2.

5.3.1 Module Burn-in - All LED modules or the electronic circuitry sub-assemblies, including all LEDs, shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, in an ambient temperature of 60°C (+140°F).

5.3.2 Maintained Minimum Luminous Intensity - All LED modules shall be tested for maintained minimum luminous intensity after burn-in. A single point measurement with a correlation to the intensity requirements of Table 1 in Section 3.0 may be used. The LED module shall be operated at nominal operating voltage and at an ambient temperature of 25°C (77°F).

5.3.3. Power Factor - All LED modules shall be tested for power factor after burn-in per the requirements of Section 4.6.1. A commercially available power factor meter may be used to perform this measurement.

5.3.4 Current - All LED modules shall be measured for current flow in Amperes after burn-in. The measured current values shall be compared against current values resulting from design qualification measurements in Section 5.4.4.1. Measured current values in excess of 120 percent of the design qualification current values shall be cause for rejection.

5.3.5 Visual Inspection - All LED modules shall be visually inspected for any exterior physical damage or assembly anomalies.

5.4 Design Qualification Testing

Design qualification testing shall be performed on new LED module designs, and when a major design change has been implemented on an existing design. The minimum sample quantity of LED modules shall be as stated for each test. Failure to meet requirements of any of these tests shall be cause for rejection.

Testing shall be performed once every 5 years or when the module design or LED technology has been changed. Test data shall be retained by the testing laboratory and the LED module manufacturer for a minimum period of 5 years.

5.4.1 Burn-in - LED modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, in an ambient temperature of +60°C (+140°F) before performing any design qualification testing.

5.4.2 Maintained Minimum Luminous Intensity

5.4.2.1 After burn-in, a random sample of six LED modules shall be tested for maintained minimum luminous intensity at each of the 44 points indicated in Table 1, Section 3.0. These measurements shall be recorded at an ambient temperature of 25°C after the signal has been operated for 60 min.

5.4.2.2 After burn-in, a random sample of six LED modules shall be tested for maintained minimum luminous intensity. Signals to be tested shall be mounted in a temperature testing chamber so that the lens portion of the signal is outside the chamber and all portions behind the lens are within the chamber at a temperature of 74°C (165°F). The air temperature in front of the signal lens shall be maintained at a minimum of 49°C (120°F) during all tests.

Red and green LED modules shall be tested for luminous output at 74°C (165°F), allowing the modules to achieve thermal equilibrium for 60 minutes, while the modules are energized at nominal operating voltage, at a 100% duty cycle, a single luminous intensity measurement shall be recorded.

Yellow LED modules shall be tested for luminous output at 25°C (77°F), allowing the modules to achieve thermal equilibrium for 60 minutes, while the modules are energized at nominal operating voltage, at a 8.3% (or 1/12) duty cycle or 5 sec On/55 sec Off.

A single point correlation measurement, accounting for measurement variables, shall be made at 25°C (77°F). For Red and green a measurement shall be made at 74°C (165°F) (lens at 49°C (120°F)). The 74°C measurement factored to the 25°C measurement shall be able to be correlated to the requirements of Table 1, Section 3.0. LED modules not meeting this correlation

shall be cause for rejection.

5.4.3 Chromaticity - A sample of two LED modules shall be measured for chromaticity per the requirements of Section 3.4.2. A spectroradiometer shall be used for this measurement. The ambient temperature for this measurement shall be +25°C (+77°F).

5.4.4 Electrical

5.4.4.1 Current. - A sample of six LED modules shall be measured for current flow in Amperes. The measured current values shall be used for quality comparison of Production Quality Assurance current measurements on production modules.

5.4.4.2 Power Factor - A sample of six LED modules shall be measured for power factor per the requirements of Section 4.6.1. A commercially available power factor meter may be used to perform this measurement.

5.4.4.3 Total Harmonic Distortion (THD). A sample of six LED modules shall be measured for total harmonic distortion per the requirements of Section 4.6.2. A commercially available total harmonic distortion meter may be used to perform this measurement.

5.4.4.4 Electronic Noise. A sample of one LED module shall be tested per the requirements of Section 4.6, with reference to Class A emission limits referenced in Federal Communications Commission (FCC) Title 47, SubPart B, Section 15.

5.4.4.5 Controller Assembly Compatibility. Due to the low load current draw and high off-state impedance of LED modules, the following design qualification tests shall be performed to ensure the module design is compatible and operates properly with load current switches and conflict monitors in NEMA and Type 170 traffic signal control units.

5.4.4.5.1 Load Switch Compatibility. A sample of six LED modules shall be tested for compatibility and proper operation with load current switches. Each LED module shall be connected to a variable AC voltage supply. The AC line current into the LED module shall be monitored for sufficient current draw to ensure proper load switch operation while the voltage is varied from 80 V rms to 135 V rms. Failure of the current draw to ensure proper load current switch operation shall be cause for rejection.

5.4.4.5.2 Signal Conflict Monitor Compatibility. A sample of six LED modules shall be tested for compatibility and proper operation with signal conflict monitors. Each LED module shall be operated from a 135 V ac voltage supply. A 19.5 k@resistor shall be wired in series in the hot line between the LED module monitor and the ac power supply. A single-pole-single-throw switch shall be wired in parallel across the 19.5 k@resistor. A 220 k@shunt resistor shall be wired between the hot line connection and the neutral line connection and the neutral line connection on the LED module. Conflict monitor compatibility shall be tested by measuring the voltage decay across the 200 k@shunt resistor as follows: The single-pole-single-throw switch shall be closed, shorting out the 19.5 k@resistor, allowing the AC power supply to illuminate the LED module. Next, the switch shall be opened and the voltage across the 220 k@shunt resistor shall be measured for a decay to a value equal to or less than 10V rms within a time period equal to or less than 100 milliseconds. This test shall be repeated a sufficient number of times to ensure testing occurs at the peak of the AC line voltage cycle.

5.4.4.6 Nondestruct Transient Immunity. A sample of six LED modules shall be tested for transient immunity using the procedure described in Section 2.1.8, NEMA Standard TS 2-1992.

5.4.5 Environmental

5.4.5.1 Temperature Cycling. Temperature cycling shall be performed on a sample of three LED modules per MIL-STD-883, Test method 1010. The temperature range shall be per Section 2.3. A minimum of 20 cycles shall be performed with a 30-minute transfer time between temperature

extremes and a 30-minute dwell time at each temperature. LED modules under test shall be non-operating. Failure of a LED module to function properly or any evidence of cracking of the LED module lens or housing after temperature cycling shall be cause for rejection.

5.4.5.2 Moisture Resistance. Moisture resistance testing shall be performed on a sample of three LED modules per NEMA Standard 250-1991 requirements for Type 4 enclosures.

5.4.5.3 Mechanical Vibration - Mechanical vibration testing shall be performed on a sample of three LED modules per MIL-STD-883, Test Method 2007, using three 4-minute cycles along each x, y, and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens, of any internal components, or other physical damage shall be cause for rejection.

(6) WARRANTY

6.1 LED modules shall be replaced or repaired by the manufacturer if an LED module fails to function as intended due to workmanship or material defects within the first 60 months from the date of being put into field operation at no cost (including shipping) to the county.

6.2 LED modules which exhibit luminous intensities less than the minimum values specified in Table 1 Section 3.0 within the first 60 months of the date of being put into field operation, shall be replaced or repaired, at no cost (including shipping) to the county.

6.3 At the discretion of City of Memphis Traffic Signal Maintenance department, the City of Memphis shall yearly select up to 2% of the LED modules installed in the field from this purchase to be tested by the manufacturer for the current luminous intensity of each unit. Shipping to and from the manufacturer and actual costs of the tests will be bourne by the manufacturer.

(7) SAMPLES - Sample modules representative of typical average production units, shall be provided for Traffic Engineering Division approval if requested. Samples will not be returned unless requested by the vender.

(8) DOCUMENTATION - Bidders shall be required to submit a copy of a test report certified by an independent laboratory (Intertek Testing Services ETL Semko) that the LED traffic signal lamp model submitted meets I.T.E. Standards for light distribution, chromaticity, and power (consumption, power factor and harmonic distortion) with the bid. In addition, the independent lab report shall specify the drive current being supplied to individual LED's within the unit. Designs that require LED's to be operated at currents greater than the LED manufacturer's recommended drive current will not be allowed.

(9) PRODUCT QUALIFICATION - All 12" balls and arrows bid shall have a total installed base in the United States, of a minimum of 25,000 lamps of each model and series number for one year prior to bid date.

(10)CONNECTED WATTAGE- Wattage and power savings are critical. The maximum acceptable wattage for the individual retrofits is listed below. Proposed LED retrofit modules, shall be less than or equal to the base wattage shown below.

Retrofit	Wattage
12" Red Ball	10 or less
12" Yellow Ball	22 or less
12" Green Ball	12 or less
12" Yellow Arrow	11 or less
12" Green Arrow	5 or less
8" Red Ball	5 or less
8" Yellow Ball	13 or less
8" Green Ball	6 or less

11.02. Pedestrian Signal

(1) PRODUCTS

1.1 General - Pedestrian LED traffic signal modules shall be designed as a retrofit replacement for the message bearing surface of a 12" x 12" pedestrian traffic signal housing built to the PTCSI Standard. The message-bearing surface of the module shall be supplied with "HAND" and "MAN" outline and overlapping symbols that comply with PTCSI standard for this symbol for a message-bearing surface of the size specified. This message-bearing surface shall be designed so that it can be removed from the sealed unit for replacement without further damage to the module.

1.2 Installation

1.2.1. LED pedestrian signal modules shall be designed as retrofit replacements for the existing pedestrian signals.

1.2.2 LED pedestrian signal modules shall not require special tools for installation.

1.2.3 LED pedestrian signal modules shall fit into the existing traffic housings built to the VTCSH Standard without any modification to the housing.

1.2.4 LED pedestrian signal modules shall be weather tight, fit securely in the housing and shall connect directly to existing electrical wiring.

1.2.5 Installation of a replacement LED module into the existing pedestrian housing shall only require the removal of the existing optical unit components, i.e., lens, lamp, gaskets, and reflector.

1.2.6 Each retrofit shall include all necessary components to complete conversion including an installed one-piece gasket.

1.2.7 Each pedestrian module shall have a sticker attached stating compliance to the ITE Standard for color.

1.3 LED Signal Lens

1.3.1 The lens of the LED pedestrian signal modules shall be polycarbonate UV stabilized and a minimum of $^1/_8$ " thick.

1.3.2 The exterior of the lens of the LED pedestrian signal module shall be smooth and frosted to prevent sun phantom.

1.4 LED Pedestrian Stgnal Module Construction

1.4.1 The LED pedestrian signal module shall be a single, self-contained device, not requiring on-site assembly for installation into the existing traffic signal housing.

1.4.2 All Portland Orange or red LEDs shall be "AlInGaP" technology or equal, and rated for 100,000 hours or more at 25°C and 20 mA. "ALGaAS " technology is not acceptable. All white or green LED's shall be "INGan " technology.

1.4.3 All internal LED and electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

1.4.4 The signal module shall be made of UL94VO flame-retardant materials. The lens is excluded from this requirement.

1.4.5 Each individual LED traffic module shall be identified for warranty purposes with the manufacturer's trade name, serial number and operating characteristics, i.e., rated voltage, power consumption, and volt-ampere.

1.5 Environmental Requirements

1.5.1 The LED pedestrian signal modules shall be rated for use in the ambient operating temperature range of -40°C to +60°C (-40°F to +140°F).

1.5.2 The LED pedestrian signal modules, when properly installed with gasket, shall be protected against dust and moisture intrusion per requirements of NEMA Standard 250-1991, sections 4.7.2.1 and 4.7.3.2, for type 4 enclosures to protect all internal LED, electronic, and electrical components.

1.6 Luminous Intensity

1.6.1 Each module shall provide an average luminous of at least 3750 candela per square meter of lighting surface for the "HAND", and 5300 candela per square meter for the "WALKING PERSON" symbol throughout the warranty period over the operating temperature range.

1.6.2 The luminous intensity of the LED pedestrian signal module shall not vary more than ± 10 % for voltage range of 80 VAC to 135 VAC.

1.7 Cromaticity - The measured chromaticity coordinates of the LED signal modules shall conform to the chromaticity requirements of Section 5.3 and Figure C of the PTCSI standard.

1.8 Electrical

1.8.1 The secured, color coded, 914 mm (36 in) long, 600V, 20 AWG minimum, jacketed wires, conforming to the National Electrical Code, rated for service at +105°C, ½ inch stripped and tinned are to be provided for electrical connection.

1.8.2 The LED pedestrian signal module shall operate from a 60 ±3 Hz AC line over a voltage range of 80 VAC to 135 VAC. Rated voltage for all measurements shall be 120 ±3 volts rms.

1.8.3 The LED circuitry shall prevent perceptible flicker over the voltage range specified above.

1.8.4 The LED pedestrian signal module circuitry shall include voltage surge protection against high-repetition noise transients and low-repetition noise transients as stated in Section 2.1.6, NEMA Standard TS-2, 1992.

1.8.5 Catastrophic failure of one LED light source shall not result in the loss of more than the light from that one LED.

1.8.6 The LED pedestrian module shall be operationally compatible with the currently used controller assemblies. The LED pedestrian module shall be operationally compatible with all conflict monitors.

1.8.7 The LED pedestrian module including its circuitry must meet Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of noise.

1.8.8 The LED pedestrian module shall provide a power factor of .90 or greater over the operating voltage range and temperature range specified above for modules with 6 watts or more.

1.8.9 Total harmonic distortion (current and voltage) induced into an AC power line by an LED pedestrian module shall not exceed 20% over the operating voltage range and temperature range specified above.

(2) QUALITY ASSURANCE - LED pedestrian modules shall be manufactured in accordance with a Vendor quality assurance (QA) program including both design and production quality assurance. All QA process and test results documentation described below shall be kept on file for a minimum of seven years.

2.1 Production Quality Assurance - The following Production Quality Assurance tests shall be performed on each new LED signal module prior to shipment. Failure to meet requirements of any tests shall be cause for rejection.

2.1.1 Pedestrian Module Burn-In – All LED signal modules (or boards) shall be energized for a minimum of 24 hours, at 100 percent duty cycle, in an ambient temperature of 60°C (140°F).

2.1.2 After burn-in, all LED pedestrian modules shall be tested for rated initial luminous intensity. Each module shall be energized at the rated voltage for a five-minute stabilization period before measurement is made. The ambient temperature for this measurement shall be the ambient operating temperature range of -40°C to +60°C (-40°F to +140°F).

2.1.3 After burn-in, all LED pedestrian modules shall be tested for power factor and shall meet the requirements defined in this specification.

2.1.4 After burn-in, all LED pedestrian modules shall be measured for current flow in amperes. The measured current values shall not exceed 110% of the design qualification measurements (described in the next section).

2.1.5 All LED pedestrian modules shall be visually inspected for any exterior physical damage or assembly anomalies. Careful attention shall be paid to the surface of the lens to ensure there are no scratches, cracks, chips, discoloration, or other defects.

2.2 Design Qualification Testing - Design Qualification testing described below shall be completed documented and submitted with the equipment quotation. All Design Qualification testing shall be performed after a burn-in (module energized for a minimum of 24 hours, at 100 percent duty cycle, in an ambient temperature of +60°C (+140°F).

2.2.1 The LED pedestrian modules shall be measured for wattage by an independent testing laboratory.

2.2.2 The LED pedestrian module shall be measured for chromaticity per the requirements defined in this specification using a spectrometer at an ambient temperature of +25°C (+77°F).

2.2.3 The LED pedestrian modules shall be measured for power factor per the requirements defined in this specification by an independent testing laboratory.

2.2.4 The LED modules shall be measured for total harmonic distortion per the requirements defined in this specification by an independent testing laboratory.

2.2.5 The LED pedestrian modules shall be tested for electronic noise per the requirements defined in this specification with reference to Class A emission limits referenced FCC Title 47 Subpart B, Section 15 by an independent testing laboratory.

2.2.6 The LED pedestrian modules shall be tested for transient immunity (e.g. early electronic component mortality failures, component reliability problems) using NEMA Standard TS 2-1992 by an independent testing laboratory.

2.2.7 Mechanical vibration testing shall be performed on the LED pedestrian modules, by an independent testing laboratory, in accordance with MIL-STD-883, Test Method 2007, using three 4 minute cycles along each x, y, z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens, of any internal components, or other physical damage shall be cause for rejection.

2.2.8 Temperature cycling shall be performed on the LED pedestrian modules, by an independent testing laboratory, in accordance with MIL-STD-883, Test Method 1010. Using the temperature range of -40°C to +60°C (-40°F to +60°F), twenty cycles (minimum) with a thirty-minute transfer time between temperature extremes and with a thirty minute dwell time at each extreme shall be performed. Modules under test shall not be energized. Modules that fail to function properly or

show evidence of cracking of the lens or housing shall be rejected.

NOTE: With respect to design changes, if the construction of the modules has not been modified, documentation of testing described in items e, g, and h on older models is acceptable at time of bid.

(3) MANUFACTURER QUALIFICATIONS - Manufacturer/Distributor/Vendor must have experience with furnishing LED lighting for the installation of at least 5,000 LED traffic signals on any one project.

(4) WARRANTY

2.4.1 The unit shall be repaired or replaced by the contractor if it exhibits a failure due to workmanship or material defect within the first 60 months of delivery.

2.4.2 The unit shall be repaired or replaced if the intensity level falls below the requirements specified in 1-E part a, within 60 months of delivery.

(5) DOCUMENTATION - Bidders shall be required to submit a copy of a test report certified by an independent laboratory (Intertek Testing Services ETL Semko) that the LED traffic signal lamp model submitted meets I.T.E. Standards for light distribution, chromaticity, and power (consumption, power factor and harmonic distortion) with the bid. In addition, the independent lab report shall specify the drive current being supplied to individual LED's within the unit. Designs that require LED's to be operated at currents greater than the LED manufacturer's recommended drive current will not be allowed.

SECTION 12. FIBER OPTIC COMMUNICATIONS CABLE AND EQUIPMENT

(1) GENERAL

This work shall consist of furnishing, installing, and testing fiber optic cable in accordance with these Special Provisions and as shown on the Plans. The work includes all materials associated with the installation of fiber optic cable including distribution equipment, splicing, and fiber optic jumper cables.

Fiber optic cable, jumper cable, and distribution equipment shall be fabricated by a certified ISO 9001 manufacturer. All fiber optic cable provided under this Contract shall be from the same manufacturer utilizing identical specifications. All fiber optic cables shall be dielectric.

(2) MATERIALS

2.1 Fiber Optic Cable - Fiber optic cable shall contain single mode optical fibers, loose tube, filled with a water–blocking material, and shall be suitable for installation in underground conduit and field cabinets. Fiber optic cable shall comply with the requirements of RUS 1755.900 except as modified herein.

2.1.1 Optical Fiber Physical and Performance Requirements - All optical fiber in the cable shall, as a minimum, comply with the following requirements:

- Cladding diameter: 125 ± 1.0 µm
- Core–to–cladding offset: ≤ 0.8 µm
- Cladding non–circularity: ≤ 1.0 percent
- Maximum attenuation: ≤0.35 dB/km at 1310 nm; ≤ 0.25 dB/km at 1550 nm
- Microbend attenuation (1 turn, 32 mm dia.): ≤ 0.5 dB at 1550 nm
- Microbend attenuation (100 turns, 75 mm dia.): ≤ 0.05 dB at 1310 nm
- Attenuation uniformity: no point discontinuity greater than 0.1 dB at either 1310 nm or 1550 nm
- Mode–field diameter (matched cladding): 9.3 ± 0.5 µm at 1310 nm; 10.5 ± 1.0 µm at 1550 nm
- Maximum chromatic dispersion: ≤ 3.2 ps/(nm x km) from 1285 nm to 1330 nm and < 18 ps/(nm x km) at 1550 nm

- Fiber polarization mode dispersion: ≤ 0.5 ps/(km)$^{1/2}$
- Fiber coating: dual layered, UV cured acrylate applied by the fiber manufacturer
- Coating diameter: 245 µm ± 10 µm
- Minimum storage temperature range: –40°F to +158°F
- Minimum operating temperature range: –4°F to +158°F

The change in attenuation for single–mode from –4°F to +158°F shall not exceed 0.2 dB/km at 1550 nm, with 80 percent of the measured values no greater than 0.1dB/km at 1550 nm.

2.1.2 Fiber Optic Cable Life Expectancy - The cable design shall achieve a life expectancy of 20 years when installed to manufacturer's specifications.

2.1.3 Buffer Tubes

Optical fibers shall be contained inside a loose buffer tube. Each buffer tube shall contain 6 fibers for cable sizes less than or equal to 36, larger cable sizes shall contain 12 fibers as shown on the Plans. The buffer tubes shall allow free movement of the fibers without fiber damage during installation or normal operation, including expansion and contraction of the buffer tubes. The diameter of all buffer tubes in a cable shall match.

Each buffer tube shall be filled with a non–hygroscopic, non–nutritive to fungus, electrically non–conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.

2.1.4 Stranding - Buffer tubes shall be stranded around a central member using the reverse oscillation, or "S–Z", stranding process. When less than 5 buffer tubes are required in the loose tube cable, filler rods shall be included in the cable core to lend symmetry to the cable cross–section. The diameter of the filler rods shall match the diameter of the buffer tubes.

2.1.5 Central Strength Member - The cable shall have a central member designed to prevent buckling of the cable.

2.1.6 Cable Core - The cable core interstices shall be filled with a non–nutritive to fungus, electrically non–conductive, water–blocking material such as water–swellable tape that is dry to the touch. The water blocking material shall be free from dirt and foreign matter.

2.1.7 Cable Rip Cord - The cable shall contain at least one (1) ripcord under the sheath for easy sheath removal.

2.1.8 Tensile Strength Members - The cable shall have tensile strength members that minimize cable elongation due to installation forces and temperature. The cable shall withstand a 607lb tensile load applied per EIA–455–33. The change in attenuation shall not exceed 0.2dB during loading and 0.1dB after loading. The cable shall be rated for an installed tensile service load of 200lb or more.

2.1.9 Cable Jacket - The cable jacket shall be dielectric (with no armoring) and consist of either high density polyethylene (HDPE) or medium density polyethylene (MDPE). Jacketing material shall be applied directly over the tensile strength members and water–blocking material.

2.1.10 Cable Markings - The markings that are provided on the fiber optic cable jacket shall include cable length markings and the year of manufacture. In addition, the cable shall be tagged with a label identifying the cable as belonging to the City of Brentwood (see Plan Drawing No. D03).

2.1.11 Environmental

The fiber optic cable shall be capable of withstanding the following conditions without damage or decrease in function:

- Cable freezing per EIA/TIA–455–98–A.
- Total immersion in water with natural mineral and salt contents.
- Salt spray or salt water immersion for extended periods.
- Wasp and hornet spray.

2.1.12 Connectors

Connectors shall be ST type throughout the fiber optic installation. The measured attenuation of the connector (inclusive of coupler and mated test connector) shall not exceed an average of 0.3 dB for all connectors provided. Any connector found in excess of 0.5 dB will be rejected. Reflectance shall be less than –40 dB, from 14°F to 140°F (–10°C to +60°C).

The connector shall be able to withstand an axial pull of 25lb with no physical damage to the connector and no permanent optical degradation more than 0.3 dB. Connectors shall be pre–wired by the manufacturer.

2.1.13 Fiber Optic Jumper Cables

Jumper cables shall match the fiber type it is attaching to (SM), and shall at a minimum, comply with the following requirements:

- 250 um buffering of each fiber.
- 900 um buffering of each fiber applied after the initial 250 um buffering.
- Maximum factory measured insertion loss of 0.5 dB per EIA/TIA 455–171.
- Less than 0.2 dB loss when subjected to EIA/TIA–455–1B, 300 cycles, 0.5 kg.
- Aramid yarn strength member.
- Rugged PVC sheathing.
- Minimum bend radius of 320 mm following installation, 640 mm during installation.
- Minimum tensile strength of 100 lbf.
- Connectors pre–wired by the manufacturer with strain relief.
- Compliance with NEC requirements for indoor fiber optic cable.

Jumper cables shall be either single fiber or duplex. Duplex jumper cables shall have permanent markings to distinguish between the fibers or connectors.

2.1.14 Connector Modules

Connector Modules shall consist of a connector panel, couplers, protective housing, and a multi–fiber pigtail cable. Connector modules shall be completely assembled and pre–wired by the manufacturer. The measured attenuation of the connector module (inclusive of coupler, fiber, and mated ST test connector) shall not exceed an average of 0.3 dB for all connector modules provided. Any connector module found in excess of 0.5 dB will be rejected. Connector modules shall comply with the following:

- 6 couplers for ST applications.
- 250 µm buffering of each fiber.
- 900 µm buffering of each fiber applied after the initial 250µm buffering.
- Provided with pre–wired, multi–fiber cable of sufficient length to facilitate fusion splicing in a splice tray that is removed from the fiber optic splice unit.
- Have a durable housing that provides physical protection and strain relief for the termination of the multi–fiber cable to couplers.
- Be easily installed and removed from the termination housing.
- Furnished with protective covers for couplers on the jumper cable side.
- Comply with NEC requirements for indoor fiber optic cable.

There shall be a fixed correlation between each buffered fiber color and coupler position for all connector modules. Fiber color shall meet the requirements for outdoor fiber optic cable.

2.2 Splices

2.2.1 Splice Trays - Splice Trays shall be designed specifically for housing single–mode fusion splices protected by heat–shrink sleeves. Splice trays shall be easily installed and removed from the fiber optic splice unit. Each splice tray shall have provisions for entry of two (2) fully jacketed multi–fiber cables from the connector modules, and two (2) buffer tubes from the distribution cable.

2.2.2 Integrated Fiber Optic Splice and Termination Units

Integrated Fiber Optic Splice and Termination Units shall consist of a single housing with provisions for connector modules, and splice trays. The integrated splice and termination unit shall have provisions for a minimum capacity of 24 fusion splices and 12 terminations using splice trays and connector modules. Connector modules shall face to the front of the rack.

The integrated splice and termination unit shall have a pull–out shelf that allows easy access to the splice tray, buffer tube and fiber storage area that permits fusion splicing to be conducted at a minimum distance of 15 feet from the housing. Units with hinged shelves are not acceptable. The following permanent marking shall be provided on the door or front access panel: "Communication Fiber Optic Cable Termination and Splice Area Inside".

Fiber optic splice and termination units shall be properly sized for the required number of splices and terminations subject to the minimum requirements stated for each configuration. The fiber optic splice and termination units shall meet the following requirements:

- Have provisions for minimum of six (6) fiber optic cable entries.
- Have provisions for internally securing the fiber optic cable sheath and central strength member for a minimum of 12 fiber optic cables.
- Rack mounted.
- Have front and rear doors or removable panels.
- Have a top, bottom, and four (4) sides that fully enclose the interior and protect its contents from physical damage.
- Manufactured using 16 gauge aluminum or equivalent and corrosion resistant.
- Provisions for neatly routing cables, buffer tubes, and fan–out tubing.
- Have cable management brackets or rings integral to the unit to secure and route cables from the connector modules and splice trays to the vertical rack members while maintaining a minimum 38 mm cable radius.

2.2.3 Fiber Optic Splice Units

Fiber Optic Splice Units shall consist of a single housing with provisions for installation of multiple splice trays as required. The splice unit shall have provisions for future installation of 3 splice trays of minimum 24 splice capacity each, in addition to the required amount. Internal, externally protected feed–through provisions are required for routing of the fiber from the splice unit to the termination unit.

The splice unit shall have a pull–out shelf that allows easy access to the splice tray, buffer tube and fiber storage area that permits fusion splicing to be conducted at a minimum distance of 15 feet from the housing. Units with hinged shelves are not acceptable. The following permanent marking shall be provided on the door or front access panel: "Communication Fiber Optic Cable Splice Area Inside".

2.2.4 Fiber Optic Termination Splice Units

Fiber Optic Termination Units shall consist of a single housing with provisions for installation of one or more connector modules as required. The termination unit shall be configured to have a minimum capacity of 12 terminations. Connector modules shall face to the front of the rack. The

following permanent marking shall be provided on the front of the unit: "Communication Fiber Optic Cable Termination Area Inside".

(3) CONSTRUCTION REQUIREMENTS

3.1 Cable length and shipping requirements

Cable shall be furnished in one (1) continuous length per reel, and shall be free from optical splices. A minimum length of 6 feet on each end of the cable shall be accessible for testing. Information accompanying the reel shall include the following either stenciled or lettered on the reel, or provided on a weatherproof tag firmly attached to the reel:

- Factory order number
- Job number
- Ship date
- Manufacturer's cable code
- Type of cable (single mode, outdoor, indoor)
- Beginning and ending length markings
- Measured length and attenuation

3.2 Installation of Fiber Optic Cable

The fiber optic cable shall be installed in conduit, cabinets, pullboxes, and facilities as shown in the Plans and in accordance with manufacturer's installation techniques and procedures. The Contractor shall furnish and install all jumper cables and termination equipment that are functionally necessary to connect fiber optic cable to the required end equipment. The contractor shall install one No. 6 green, unspliced THW/XHHW tracer wire in each conduit. Lubricants used in pulling the tracer wire shall be water soluble. A minimum of 5 feet of tracer wire shall be coiled and secured in the pull box on each end of the conduit run. The ends of the tracer wire in the pull box shall be connected to the grounding wire in the pull box.

The Contractor shall install fiber optic cable as a continuous run and splice only at locations shown on the plans. The Contractor shall determine the length of fiber optic cable necessary to reach from one end of the cable run to the other end of the cable run, including cable slack requirements. The Contractor shall label all fiber optic cables at each end of the cable run, at the point the cable enters a cabinet and at the point the cable exits the cabinet for mid–cable access locations, and in all pull boxes. All labels for fiber optic cables shall identify the cable number and the string numbers of the fibers contained within the cable.

Installation of fiber optic cable and jumper cable indoors shall meet the minimum requirements of local building codes and NEC Article 770, inclusive of the Fine Print Notes (FPN). The cable shall not be pulled along the ground or over or around obstructions. Optical cable shall not be pulled over edges or corners, over or around obstructions, or through unnecessary curves or bends. Bend radius criteria of 10 times the cable diameter under no stress and twenty times cable diameter under stress shall not be exceeded. Manufacturer approved pulling grips, cable guides, feeders, shoes, and bushings shall be used to prevent damage to the cable during installation.

When cable is removed from the reel prior to installation, it shall be placed in a "figure–eight" configuration to prevent kinking or twisting. Care shall be taken to relieve pressure on the cable at the crossover by placing cardboard shims (or equivalent method) or by creating additional "figure–eights".

Before installing any fiber optic cable in conduit, the Contractor shall provide the Engineer the cable manufacturer's recommended and maximum pulling tensions. Included with these pulling tensions shall be a list of the cable manufacturer's approved pulling lubricants. Lubricants shall be used in quantities and in accordance with the procedures recommended by the lubricant manufacturer.

Before installing any fiber optic cable in conduit, all cable pulling equipment shall be approved by the Engineer and the cable manufacturer. The cable pulling equipment shall come with a meter to display pulling tension and a mechanism to ensure that the maximum allowable pulling tension cannot be exceeded at any time during installation.

The Contractor shall furnish attachment hardware, installation guides, and other necessary equipment, not specifically listed herein, as necessary to install the fiber optic cable.

Fiber optic cable in pull boxes shall be appropriately looped and tied to the side wall.

Fiber optic cable shall be routed to the field cabinets as shown on the plans. This shall include all work required to cut or drill into an existing foundation and install a new conduit entrance into the foundation. Concrete cuts shall not be more than 1" greater than the diameter of the conduit being installed. All concrete cuts shall be filled with grout. The existing foundation may be either a pole foundation, or a cabinet foundation. The conduit shall be paid for separately.

3.3 Splicing Methods

All splices shall be accomplished by means of the fusion splice technique and shall not induce more than 0.1 dB attenuation for each splice, and 0.07 dB average for all splices. Splices found to exceed 0.1 dB attenuation shall be re–spliced, at no additional cost to the County, by the Contractor until this requirement is met.

Each splice shall be packaged in a protective sleeve or housing and secured in splice trays located in the fiber optic splice unit or integrated fiber optic splice and termination unit. Bare fibers shall be completely re–coated with a protective heat–shrink coating prior to placement in a sleeve or housing. Heat shrink coating type shall be as recommended by the manufacturer of the fiber optic cable. The heat–shrink coating shall be approved for use by the fiber optic cable manufacturer and installed in such a manner as to protect the fiber from scoring, dirt accumulation, moisture intrusion, and micro–bending.

The Contractor shall only splice fibers at locations that are identified in the Plans. All splices shall be protected and stored in fiber optic splice units or integrated fiber optic splice and termination units that are housed in field cabinets, or facilities.

The fully sheathed, multi–fiber cable of each connector module shall be routed into and secured in a splice tray.

Fiber optic cable shall enter the rear of the fiber optic splice unit or integrated fiber optic splice and termination unit. The fiber optic cable sheath and central member shall be secured inside the unit prior to buffer tube fan–out. All entry holes not utilized shall be plugged. Buffer tubes with fiber designated for splicing shall be routed into and secured in a splice tray. Remaining buffer tubes shall be secured within the splice unit and not accessed.

- **Mid–cable access:** Only fibers within a buffer tube that are designated for splicing shall be individually accessed, spliced to the appropriate fibers from the connector module(s), and secured neatly within the splice tray. The remaining fibers in the buffer tube that are not designated for splicing shall be secured neatly within the splice tray and not cut. Removal of the buffer tube to access the fibers shall be accomplished using equipment specifically designed for buffer tube removal without damaging the individual coated fibers (Corning OFT–000 or equivalent).

- **Full–cable termination:** All fibers including spares, shall be spliced to the appropriate fibers from the interconnect cable and pigtails, and secured neatly within the splice tray.

Termination of distribution fiber shall be accomplished by splicing the distribution fiber to the appropriate fiber from a connector module. Field termination of fibers to connectors by the Contractor will not be permitted unless otherwise approved by the Engineer.

Measured attenuation at each termination (inclusive of 2 connectors and coupler), shall not exceed 0.5 dB.

Fiber terminations shall be neatly and permanently labeled on the connector module to designate transmit or receive (when appropriate) and the string number. Spare fibers shall be labeled as "spare" with the string number.

Blank connector panels, of same finish and manufacture as the connector modules shall be installed for all unused connector module spaces.

Until jumper cables are installed, the Contractor shall provide and maintain protective covers over the optical connectors and termination. Protective covers on terminations not used shall remain.

Jumper cables shall be installed from connector module to end equipment, and from end equipment to end equipment in multiple cabinet configurations. Jumper cables shall be secured to provide strain relief at both the connector module and the end equipment. Manufacturer recommended installation and minimum bend radius requirements shall be adhered to. Jumper cables, which connect to end equipment, shall be labeled at both ends. At field cabinet locations, the label at both ends shall contain the string number, the ring number, transmit or receive, and primary or secondary.

(4) PAY ITEM AND METHOD OF MEASUREMENT

4.1 Single mode fiber optic cable shall be measured in linear feet and will be paid for at the Contract unit price per linear foot. This price shall include all materials, labor, tools, equipment, backlashing, and incidentals necessary to complete the work, and all testing and documentation.

4.2 Fiber Optic Termination and Splice Units shall be measured in units of each and will be paid for at the Contract unit price per each. Termination units shall contain the necessary fiber optic connector modules, splice trays, and associated splicing for locations indicated on the Plans. This price shall include all materials, labor, tools, equipment, and incidentals necessary to complete the work, and all testing and documentation.

SECTION 13. FLASHER CONTROLLER SPECIFICATIONS

1. SCOPE:

This specification covers minimum acceptable materials and workmanship for a flasher controller in cabinet. It shall be furnished with a standard NEMA electronic flasher relay complete with base, A 15 amp circuit breaker, a terminal strip for field wiring, a radio interference line filter, and transient spark suppression on both field lines and the AC service.

2. CABINET:

2.1 The cabinet shall be cast aluminum. It shall be vented by screened vents located in top of cabinet in such a manner as to exclude entrance of precipitation and at least one 1-1/2" screened vent in bottom of cabinet located one side of center by at least 3 inches so as not to interfere with conduit entrance in bottom of cabinet.

2.2 The minimum cabinet inside dimensions shall be 12 inches wide x 12 inches high x 7 inches deep.

2.3 The complete cabinet shall be painted with a zinc chromate primer and two (2) coats of high grade aluminum paint inside and out.

2.4 The main door shall have a Corbin pin-tumbler cylinder lock conforming to the Shelby County Master Key; The Shelby County Key Code shall be furnished the successful bidder at time of award of contract. One (1) key shall be provided with each controller cabinet.

2.5 The cabinet shall be equipped with a radio interference filter installed at the electric service line input. The filter shall provide a minimum electrical noise attenuation of 50 decibels over the range of 200 kilohertz to 75 megahertz.

2.6 The AC + service line cabinet terminal shall be suppressed with a 150 volt MOV across the line side to ground. Each AC + Signal Display Field Terminal shall have a 150 volt varistor (E MOV #150LA 20A or equal) installed across it to ground.

2.7 All barrier terminal blocks shall be Cinch type 150 with numbering strip or equal. This type and size terminal block shall be provided for all field connectors. Terminal blocks shall consist of barrier terminal pairs using a 10-32 size screw with the center-to-center distance between terminal pairs being 5/8 inch.

2.8 A ground neutral buss with multiple screw terminals for 12 gauge copper signal neutrals and 4 gauge copper earth connection shall be installed.

2.9 Field connectors shall be made at the bottom rear of the cabinet on horizontal terminal strips. Terminal strip blocks shall be positioned not less than two inches nor more than 4 inches from the cabinet bottom.

2.10 The cabinet shall be wired in a neat and orderly fashion with all wiring bundled to form a wiring harness attached to the back panel. The terminal strip shall provide for connection of the following circuits:

Four flasher outputs for field connection (two sets of the two circuit flasher outputs) and one circuit to provide a steady 120 VAC to indicate that the school flasher is in the active mode.

3. FLASHER:

The cabinet shall be furnished with and wired for a jack-mounted 120 VAC, dual circuit, all solid-state flasher unit. The flasher shall have a duty cycle of 50 percent at a flash rate of 1 cycle per second. The flasher shall be rated 25 amperes at 120 VAC. A heat sink shall be made part of the flasher body. The flasher shall be a Standard NEMA type.

4. Each bid shall be accompanied by engineering and operational specifications for the equipment bid. Each bidder may be required to furnish a controller for evaluation. If a bidder is requested to furnish a sample controller, it shall be furnished to the County within 15 days of date requested. If the equipment is not submitted as required, the County may reject that bid. All material, parts and workmanship shall be guaranteed for a period of one year after field installation with defective equipment either repaired or replaced entirely at bidder's expense.

4.1 Before fabrication of the cabinets is begun, the successful bidder shall submit for approval three (3) copies of complete shop drawings of the cabinet including component and wiring layout.

4.2 The supplier shall provide detailed technical circuit description and circuit schematic information applicable to the operation and maintenance of the controller and associated auxiliary equipment. Cabinet wiring diagrams with interconnection details, schematics and maintenance techniques shall be furnished. Information in manual form shall include a material guide which shall contain the replacement part numbers and description of all components used. All solid-state devices shall be listed by their generic name or, in lieu of this, a complete cross-index from manufacturers numbers to generic numbers shall be provided. Parts list shall be itemized with the respective chassis, module or circuit wherein parts may be found.

A total listing of parts without grouping shall be unacceptable. Schematic circuit drawings shall be furnished that are slow to fade when exposed to sunlight over long periods of time. A developed and fixed printing process or one of the forms of printing by actual ink transfer will be acceptable.

SECTION 14. SCHOOL FLASHER SPECIFICATIONS

1. SCOPE:

This specification covers minimum acceptable materials and workmanship for a school flasher controller in cabinet.

It shall be furnished with an on and off switch, a timer that will automatically turn the flasher off after a predetermined time, a standard two circuit NEMA electronic flasher load switch relay complete with base, a 15 amp circuit breaker, a terminal strip for field wiring, a radio interference line filter, and transient spark suppression on both field lines and the AC service.

2. CABINET:

2.1 The cabinet shall be cast aluminum. It shall be vented by screened vents located in top of cabinet in such a manner as to exclude entrance of precipitation and at least one 1-1/2" screened vent in bottom of cabinet located one side of center by at least 34 inches so as not to interfere with conduit entrance in bottom of cabinet.

2.2 The minimum cabinet inside dimensions shall be 12 inches wide x 12 inches high x 7 inches deep.

2.3 The complete cabinet shall be painted with a zinc chromate primer and two (2) coats of high grade aluminum paint inside and out.

2.4 The main door shall have a Corbin pin-tumbler cylinder lock conforming to the Shelby County Master Key. The Shelby County Key Code shall be furnished the successful bidder at time of award of contract. One (1) key shall be provided with each controller cabinet.

2.5 The on-off switch shall be mounted in the left side of the cabinet wall and shall be keyed to existing school flasher cabinets. A key will be supplied to the successful bidder at time of award of contract. This key is different from the one described for the cabinet. Two keys shall be provided with each cabinet.

2.6 The cabinet shall be equipped with a radio interference filter installed at the electric service line input. The filter shall provide a minimum electrical noise attenuation of 50 decibels over the range of 200 kilohertz to 75 megahertz.

2.7 The AC + service line cabinet terminal shall be suppressed with a 150 Volt MOV across the line side to ground. Each AC + Signal Display Field Terminal shall have a 150 volt varistor (E MOV #150LA 20A or equal) installed across it to ground.

2.8 All barrier terminal blocks shall be Cinch type 150 with numbering strip or equal. This type and size terminal block shall be provided for all field connections. Terminal blocks shall consist of barrier terminal pairs using a 10-32 size screw with the center-to-center distance between terminal pairs being 5/8 inch.

2.9 A grounded neutral buss with multiple screw terminals for 12 gauge copper signal neutrals and 4 gauge copper earth connection shall be installed.

2.10. Field connectors shall be made at the bottom rear of the cabinet on horizontal terminal strips. Terminal strip blocks shall be positioned not less than two inches nor more than 4 inches from the cabinet bottom.

2.11 The cabinet shall be wired in a neat and orderly fashion with all wiring bundled to form a wiring harness attached to the panel. The terminal strip shall provide for connection of the following circuits:

Four flasher outputs for field connection (two sets of the two circuit flasher outputs) and one circuit to provide a steady 120 VAC to indicate that the school flasher is in the active mode.

3. FLASHER:

The cabinet shall be furnished with and wired for a jack-mounted 120 VAC, dual circuit, all solid-state flasher unit. The flasher shall have a duty cycle of 50 percent at a flash rate of 1 cycle per second. The flasher shall be rated 25 amperes at 120 VAC. A heat sink shall be made part of the flasher body. The flasher shall be a Standard NEMA type.

4. TIMER:

The timer shall be capable of being set to a predetermined time settable from 2 to 60 minutes in one minute

increments. The timing event shall be initiated by the keying "on" of the on-off switch and shall be terminated either by expiration of the preset time on the timer or by keying the on-off switch to the "off" position.

The timer shall be mounted in such a position that all controls and indicators face the front of the cabinet.

Quality reference for the timer is the Eagle Signal HP5 Series Cycle-Vlex (R) Reset Timer Model 9.

Output Rating of Contacts: 10 amps resistive, 120 VAC.

Power on Response: 28 ms avg. pull-in.

Drop-Out: 17 ms avg. drop-out.

Operating Temperature: +32 degrees to 140 degrees F.

Standards Recognition: UL, CSA, and F.M. approved.

5. Each bid shall be accompanied by engineering and operational specifications for the equipment bid. Each bidder may be required to furnish a controller for evaluation. If a bidder is requested to furnish a sample controller, it shall be furnished to the County within 15 days of date requested. If the equipment is not submitted as required, the County may reject that bid. All material, parts and workmanship shall be guaranteed for a period of one year after field installation with defective equipment either repaired or replaced entirely at bidder's expense.

5.1 Before fabrication of the cabinets is begun, the successful bidder shall submit for approval, three (3) copies of complete shop drawings of the cabinet including component and wiring layout.

5.2 The supplier shall provide detailed technical circuit description and circuit schematic information applicable to the operation and maintenance of the controller and associated auxiliary equipment. Cabinet wiring diagrams with interconnection details, schematics and maintenance techniques shall be furnished. Information in manual form shall include a material guide which shall contain the replacement part numbers and description of all components used. All solid-state devices shall be listed by their generic name or, in lieu of this, a complete cross-index from manufacturers numbers to generic numbers shall be provided. Parts list shall be itemized with the respective chassis, module or circuit wherein parts maybe found.

A total listing of parts without grouping shall be unacceptable. Schematic circuit drawings shall be furnished that are slow to fade when exposed to sunlight over long periods of time. A developed and fixed printing process or one of the forms of printing by actual ink transfer will be acceptable.

D-3

SHELBY COUNTY GOVERNMENT

ENGINEERING DEPARTMENT

RETAINING WALL SPECIFICATIONS

SECTION D-3

MODULAR BLOCK RETAINING WALL SPECIFICATIONS

SECTION 1. GENERAL

1.01 Work:

This item shall include the furnishing and installation of a modular block retaining wall in accordance with this specification and the construction drawings. The retaining wall shall be constructed in reasonably close conformity with the lines, grades, and details shown on the construction drawings. Payment for this work shall be covered under Item

1.02 Wall System:

The wall system supplier/manufacturer shall provide shop drawings and any design calculations for review by the design engineer. The wall system shall comply with the latest edition of the Tennessee Department of Transportation Earth Retaining Structures Manual. The face of the block shall be textured and the color of the block shall be a natural earth tone. Provisions are to be made to ensure that backfill material does not penetrate through gaps between the blocks. The wall supplier/manufacturer shall provide a written, minimum 3-year warranty for the retaining wall to the Owner to cover defects that may occur during and after construction is complete.

1.03 Backfill Material:

All backfill material used for the wall shall consist of materials, which are free from organics, or other unsuitable or deleterious material and shall be in conformance with the Tennessee Department of Transportation Earth Retaining Structures Manual.