

City of Las Cruces

STANDARD SPECIFICATIONS FOR ROAD CONSTRUCTION

2000 EDITION

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SECTION 100

GENERAL PROVISIONS

100.00 SCOPE

This publication of the City of Las Cruces Standard Specifications for Road Construction, 2000 Edition, supersedes the 1997 Edition and all previous publications of this document.

100.10 PURPOSE

These Standard Specifications have been prepared and adopted to provide essential information required for the quality construction and maintenance of roadways and related structures within the corporate limits of the City of Las Cruces, New Mexico, referred to as "the City" elsewhere herein.

100.20 SEVERABILITY

If any article, section, paragraph, sentence, phrase or part thereof is declared unconstitutional or invalid, the remaining portions shall not be affected.

100.30 INTERPRETATION

These Standard Specifications shall be considered the minimum requirements to meet the purpose expressed in section 100.10 of these provisions.

Where the provisions of any local ordinance, regulation, or covenant imposes greater restrictions than those of these Standard Specifications, the provisions of such document shall prevail.

When there is a conflict between construction plans and these Standard Specifications, the most restrictive shall apply. When two or more Standard Specifications are conflicting, the most restrictive shall apply. In the event any given specification does not exist in this document, reference shall be made to the most current edition of the New Mexico State Highway and Transportation Department Standard Specification for Highway and Bridge Construction (NMSH&TD-SSFH&BC). When these Standard Specifications conflict with the NMSH&TD-SSFH&BC, the most stringent shall apply. In the event the NMSH&TD-SSFH&BC does not address the specification, the Chief Engineer of the City of Las Cruces shall reserve the right to interpret and approve specifications, procedures, and materials.

The Chief Engineer of the City of Las Cruces or his/her designee shall interpret the meaning of all portions of these Standard Specifications. Disagreement with an interpretation may be appealed to the City Council through the Director of Development Services Division and the City Manager.

100.40 CORRELATION OF DOCUMENTS

The following order of precedence (highest to lowest) will be followed for all work done in accordance with these Standard Specifications:

1. Special Conditions (City contracts only)
2. Supplemental Specifications (City contracts only)
3. Plans
4. Standard Specifications
5. General Conditions for Construction Contracts (City contracts only)
6. Referenced Specifications

In the event a standard or specification states "as indicated on the plans", then the plans shall have precedence over that specific portion of the specifications without effecting, changing, or invalidating the remaining portions of that standard or specification.

SECTION 105

DEFINITIONS AND ABBREVIATIONS

105.10 DEFINITIONS

Act of God. - An unusual, sudden, and unexpected manifestation of the forces of nature, the effect of which could not have been prevented by reasonable human foresight, pains, and care.

Bridge. - A structure carrying a pathway or roadway over a depression or obstacle. It includes all appurtenances necessary to its proper use. The length of a bridge structure is the distance along the line of survey stationing back-to-back of backwalls of abutments, if present, or end-to-end of the bridge floor and in no case less than the total clear opening of the structure. The bridge roadway width is that clear unobstructed bridge deck available for vehicle use measured normal to the centerline of the bridge.

Conduit. - A pipe or tube used for receiving and protecting utility lines.

Culvert. - Any structure not classified as a bridge which provides an opening under a roadway.

Detour. - A temporary route for traffic around a closed portion of a road.

Divided Highway. - A highway with separated roadways for traffic, generally in opposite directions.

Embankment. - The raised portion of a roadway which is below the subbase, base course, and surface courses and which is built up in layers consisting principally of soil and broken rock or a combination thereof.

Embankment Foundation. - The natural ground or backfilled areas upon which the embankment is constructed.

Engineer. - The Engineer assigned to the project acting under direction of the City Administration or the City's Chief Engineer. The Engineer may be a City employee or an Engineer under contract to the City to administer the construction contract between the City and the Contractor and to inspect the work to insure compliance with plans and specifications.

Equipment. - All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for the proper construction and acceptable completion of the work.

Foreman - The Contractor's foreman for a specific crew, or crews, performing a specific type or classification of work. The Contractor's foreman will not be considered a Superintendent.

Highway, Street, or Road. - A general term denoting a public way for purposes of vehicular and/or pedestrian travel.

Inspector. - The Engineer's authorized representative assigned to the project to make detailed inspections of contract performance.

Laboratory.- A materials testing laboratory employed by the City to perform tests on materials to determine compliance with plans and specifications.

Materials.- Any substances specified for use in the construction of the project and its appurtenances.

Median.- That portion of a divided highway which separates the roadway.

Pavement Structure.- The combination of base course and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

Plans.- The approved plans, profiles, typical cross sections, working drawings and supplemental drawings, or exact reproduction thereof, which show the location, character, dimensions and details of the work to be done.

Project.- The specific section of the highway, street or roadway together with all appurtenances and construction to be performed thereon under the Contract.

Record Drawings. - Drawings maintained by the Contractor showing changes in horizontal or vertical location of project improvements that are installed in locations different from that shown on the plans. Record drawings shall be maintained to not more than two weeks from current project status.

Right-of-Way.- A general term denoting land, property, or interest therein usually in a strip, acquired for, devoted to, or dedicated for transportation purposes.

Roadbed.- The graded portion of the highway or street with top and side slopes prepared as a foundation for the subgrade, pavement structure, and shoulders.

Roadside.- A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

Roadside Development.- Those items necessary to complete the roadway which provide for the preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching, and the placing of other ground covers; such suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the roadway area.

Roadway.- That portion of a public way used for construction of a highway, street, or road the limits of which may include the total right-of-way.

Shoulder.- The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Sidewalk.- That portion of the roadway primarily constructed for use by pedestrians.

Specifications.- A general term applied to all provisions and requirements pertaining to performance of the work.

Standard Plans.- Reproduction of approved drawings of standard details for specific items of work.

Structures.- Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, sewers, service pipes, underdrains, foundation drains, and other features which may be encountered in the work and not otherwise classed herein.

Subgrade.- The portion of the roadbed prepared as a foundation for the pavement structure.

Substructure.- All of that part of the bridge structure below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the backwalls, wingwalls, and wing protection railings.

Superintendent.- The Contractor's representative authorized in writing to be in responsible charge of the overall project with responsibility and authority to make changes as necessary regarding equipment, labor, and method of work employed. The Superintendent will be on the jobsite during working hours.

Superstructure.- The entire bridge structure except the substructure.

Supplemental Specifications.- Approved additions and revisions to the Standard Specifications for Roadway Construction.

Traffic Lane.- The portion of a street or roadway designed for the movement of a single line of vehicles.

Work.- The furnishing of all labor, materials, equipment and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the Contract.

Working Drawings.- Documents furnished by the Contractor including, but not necessarily limited to, stress sheets, shop drawings, bending diagrams for reinforcing steel, and plans for erection, falsework, framework, cofferdam(s), and other items or data required for the successful completion of the work.

105.20 ABBREVIATIONS

AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AGC	Associated General Contractors of America
AIA	American Institute of Architects
AICS	Asphalt Institute Construction Series
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute, Inc.
APWA	American Public Works Association
ARA	American Railway Association
AREA	American Railway Engineering Association
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
AWPA	American Wood Preservers Association
AWWA	American Water Works Association
AWS	American Welding Society
FCC	Federal Communications Commission
FHWA	Federal Highway Administration, Department of Transportation
FSS	Federal Specifications and Standards, General Services Administration
HMAC	Hot-Mix Asphalt Concrete
ICC	Interstate Commerce Commission
IES	Illumination Engineering Society
IMSA	International Municipal Signal Association
IPCEA	Insulated Power Cable Engineer's Association
ITE	Institute of Traffic Engineers
MUTCD	Manual on Uniform Traffic Control Devices, Published by the United States Government Printing Office
NEC	National Electric Code
NEMA	National Electrical Manufacturer's Association
PMBP	Plant-Mix Bituminous Pavement
SAE	Society of Automotive Engineers
U.B.C.	Uniform Building Code
U.L.	Underwriters Laboratories

SECTION 110 CONTROL OF WORK

110.10 AUTHORITY OF ENGINEER

The Engineer will decide all questions which may arise as to the quality and acceptability of materials furnished and work performed, as to the rate or progress of the work, all questions which may arise as to the interpretation of the plans and specifications, and all questions as to the acceptable fulfillment of the contract on the part of the Contractor.

The Engineer has the authority to reject defective material and to suspend the work wholly or in part due to the failure of the Contractor to correct unsafe conditions, for failure to carry out provisions of the contract, for failure to carry out directions of the Engineer, for such periods as he may deem necessary due to unsuitable weather, for conditions considered unsuitable for the prosecution of the work, or for any other condition or reason deemed to be in the public interest.

The Engineer has immediate charge of the engineering details of the work. He is responsible for the administration and satisfactory completion of the work for the Contracting Agency.

The Engineer will interpret the meaning of any part of the plans and specifications about which any misunderstanding may arise, and his decision will be final.

110.20 DUTIES OF INSPECTOR

Inspectors will be authorized to inspect all work done and materials furnished. Such an inspection may extend to all or any part of the work and to the preparation, fabrication, or manufacture of the materials to be used. The Inspector will not be authorized to issue instructions contrary to the plans and specifications, or to act as foreman for the Contractor.

110.30 INSPECTION OF WORK

1. The contractor will be required to provide at least one hour notification for testing required. This time is necessary for Project Inspectors to schedule the needed work. If a test is requested and the Inspector arranges for a materials testing laboratory to go to a project site, the laboratory technician will not be required to stand by for more than 15 minutes. The technician will be instructed to do the test he was called out for and the contractor will be financially responsible for re-tests.
2. The City shall provide sufficient competent personnel, working under qualified supervision for the inspection of the work while such work is in progress to ascertain that the completed work will comply in all respects with the standards and requirements set forth in the specifications. Notwithstanding such inspection, the Contractor will be held responsible for the acceptability of the finished work.
3. The Engineer and his representatives shall at all times have access to the work whenever it is in

preparation or progress. If the specifications, Engineer's instructions, laws, ordinances, or any public authority require any work to be specially tested or approved, the Contractor shall give the Engineer

timely notice to its readiness for inspection, and if the inspection is by an authority other than the Engineer, of the date fixed for such inspection. Inspections by the Engineer shall be promptly made and where practicable at the source of supply.

4. Reexamination of any work may be ordered by the Engineer, and, if so ordered, the work must be uncovered by the Contractor. If such work is found to be in accordance with the contract documents, the Department shall pay the cost of reexamination and replacement. If such work is not in accordance with the contract documents, the Contractor shall pay such cost.
5. The Contractor shall notify the Engineer twenty-four (24) hours prior to commencing any work, or resuming work after shutdowns, except for normal resumption of work following Saturdays, Sundays, or holidays.

110.40 COOPERATION WITH OTHERS

Wherever work being done by the City's forces, utility companies, or by other contractor's forces is contiguous to work covered by this contract, the respective rights of the various interests involved shall be established by the Engineer, to secure the completion of the various portions of the work in general harmony.

110.50 RESPONSIBILITY OF CONTRACTOR

The Contractor shall give the work constant attention and supervision until the same is completed, and shall cooperate with the Engineer and the Inspectors in every way possible.

The Contractor shall have on the work at all times, as his agent, a competent superintendent capable of reading and thoroughly understanding the plans and specifications and thoroughly experienced in the type of work being performed. Such superintendent shall be furnished regardless of the amount of the work sub-let. The superintendent shall represent the Contractor, and all directions given to him shall be binding as if given to the Contractor. Important directions shall immediately be confirmed in writing to the Contractor. Other directions shall be so confirmed on written request in each case.

110.60 SURVEYING

Permanent Survey Markers. The Contractor shall notify the Engineer not less than seven (7) days prior to starting work in order that the Engineer may take necessary measures to insure the preservation of survey monuments, stakes, and bench marks. The Contractor shall not disturb permanent survey monuments, stakes, or bench marks without the consent of the Engineer, and shall notify the Engineer and bear the expense of replacing any that may be disturbed without permission. Replacement shall be done only by the Engineer.

110.70 REMOVAL OF UNACCEPTABLE WORK

The Contractor shall promptly remove from the premises all materials and work condemned by the Engineer as failing to meet contract requirements.

All removal and replacement work shall be done at the Contractor's expense.

110.80 PROTECTION AND RESPONSIBILITY FOR WORK

The Contractor assumes full responsibility for the work. Until final acceptance, the Contractor shall be responsible for damage to or destruction of the work (except for any part covered by partial acceptance) unless such damage or destruction is caused by the negligence of the City of Las Cruces.

110.90 LIGHT, POWER, AND WATER

The Contractor shall furnish temporary light, power, and water complete with connecting piping, wiring, lamps, and similar equipment necessary for the work as determined by the Engineer.

The Contractor shall install, maintain, and remove his temporary lines upon completion of work. All expenses in connection with temporary services and facilities shall be paid by the Contractor, unless otherwise provided in the contract.

110.91 EMERGENCY WORK

In an emergency affecting the safety of life or of the work or of adjoining property, the Contractor is, without special instructions or authorization from the Engineer, hereby permitted to act at his discretion to prevent such threatening loss or injury. He shall also so act, without appeal, if so authorized or instructed by the Engineer. Any compensation claimed by the Contractor on account of emergency work shall be determined by agreement or in accordance with these specifications.

110.92 WARRANTY

The Contractor shall guarantee all work performed by his contract for a period of one (1) year. Any defect that occurs shall be repaired or replaced at no cost to the Owner.

110.93 LAWS AND REGULATIONS

The contractor shall conform to all City, State, and Federal Ordinances, Laws, and Regulations.

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SECTION 115

CONTROL OF MATERIALS

115.10 MATERIALS AND WORKMANSHIP

All materials, parts, and equipment furnished by the Contractor shall be new and free from defects and imperfections unless otherwise hereinafter specified. Workmanship shall be in accord with the best standard practices. Both materials and workmanship shall be subject to the approval of the Engineer.

All materials and workmanship not conforming to the requirements of these specifications shall be considered as defective and will be rejected.

115.20 TESTS OF MATERIALS

Except as may otherwise be provided in specific instances, all testing that may be required by the City of Las Cruces to determine the quality, fitness, and suitability of such materials shall be performed at the direction, and upon the order of, the Engineer, and at no expense to the Contractor, except where tests prove that such materials do not meet the specified requirements and retests are required for this reason, the costs for such retests shall be borne by the Contractor. Samples of materials may be secured and tested whenever considered necessary by the Engineer. In certain cases where the Contractor is required to provide and bear the expense of such testing the specifications or drawings will definitely so state.

In accordance with the Materials Testing Services Agreement a Testing Technician will not be required to "stand by" for longer than fifteen (15) minutes. In the instance that additional "stand by" time is requested, the expense shall be borne by the entity requesting the additional service.

The Contractor, at his own expense, shall deliver the materials for testing at the time and to the place designated by the Engineer.

115.30 CONCRETE MIX DESIGN

The contractor shall submit a copy of an approved concrete mix design from the concrete supplier to be used on City Projects and Subdivisions. No concrete shall be placed on a project or subdivision until the Project Manager has a copy of the approved concrete mix design. The concrete supplier should have on file an original annually approved mix design which was submitted with an embossed seal and signed by a Professional Engineer Licensed in the State of New Mexico who certifies the mix design.

115.40 ASPHALT MIX DESIGN

The contractor shall submit a copy of an approved asphalt mix design from the asphalt supplier to be used on City Projects and Subdivisions. No asphalt shall be placed on a project or subdivision until the Project Manager has a copy of the approved asphalt mix design. The asphalt supplier should have on file an original annually approved mix design which was submitted with an embossed seal and signed by a Professional Engineer Licensed in the State of New Mexico who certifies the mix design.

115.50 MORTAR MIX DESIGN

The contractor shall submit a copy of an approved mortar mix design from the mortar supplier to be used on City Projects and Subdivisions. No mortar shall be placed on a project or subdivision until the Project Manager has a copy of the approved mortar mix design. The mortar supplier should have on file an original annually approved mix design which was submitted with an embossed seal and signed by a Professional Engineer Licensed in the State of New Mexico who certifies the mix design.

115.60 STORAGE OF MATERIALS IN PUBLIC STREETS, ROADS, OR HIGHWAYS

Materials shall not be stored in streets, roads, or highways for longer than four (4) working days after being unloaded, unless a longer storage period is permitted by the Engineer. In the event the rate of progress of construction is such that the materials stored in streets, roads, or highways is not installed in its final position within the time period stipulated hereinabove, the Contractor shall, when so directed by the Engineer, remove such material to storage areas to be provided by the Contractor at his own expense.

Unless otherwise permitted by the Engineer, no storage of excavated trench material will be permitted in public streets, roads, or highways for a period of time longer than necessary for the installation, testing, and inspection of the pipe line or structure being installed. After the placing and compacting of the backfill in said trench, all remaining excavated material shall be removed from the site of the work.

SECTION 120 STANDARD PROCEDURES FOR MATERIALS TESTING FAILURES

120.10 SCOPE

This section is intended as a Standard Procedure for dealing with materials testing failures on all Roadway and Drainage construction activities including contracted city projects and subdivisions. The intent of this section is to ensure consistent requirements for remedial action in the event test reports indicate materials specified in this document do not meet the specified tolerances. The procedures outlined in this section shall be used unless otherwise specified by the Engineer. The Engineer reserves the right to deviate from these guidelines if he/she feels the public health or welfare or the best interest of the City of Las Cruces is at risk.

120.20 FREQUENCY OF ASPHALT TESTS

1. Samples shall be taken to represent every 300 Tons of asphalt concrete material with a minimum of one battery of tests per site and a minimum of two per day.
 2. A battery of tests on the asphalt concrete samples shall consist of a minimum of one each of the following procedures:
 - A. Asphalt Extraction *
 - B. Gradation of Aggregate
 - C. Stability
 - D. Flow
 - E. Percent Air Voids
 - F. Unit Weight Determination
 3. Density tests shall be taken at the rate of 3 minimum per battery of tests and a minimum of 2 per site or street.
- * May substitute nuclear determination if approved by the Engineer.

120.21 ASPHALT ACCEPTANCE LOTS

1. All density tests taken in a given lot will be averaged for acceptance purposes.
2. A lot shall be defined as the smallest of the following:
 - A. a days work
 - B. per street
 - C. per site
 - D. per 3,000 yd² of area paved
 - E. per 300 tons of asphalt used
3. Tests on all variables except densities will only be given tolerances as outlined in the job mix formula and/or the specifications.

120.22 ASPHALT FAILURE RESOLUTION PROCEDURES:

1. If any of the following problems occur, the contractor will be issued a Field Notice by the City's Project Manager and ordered to stop work and remedy all problems listed in the Notice before commencing work:
 - A. If any ^{Should read "If any" of the variables"} ~~single variable~~ falls outside the tolerance listed on the mix design and/or the specifications on two consecutive reports.
 - B. If any single variable falls outside of the wide band tolerance on the mix design and/or the specifications on any single report.
2. If any of the following problems occur, the contractor will be issued a second Field Notice by the City's Project Manager and ordered to stop work. The contractor will be required to provide the City with a plan to remedy the problems before commencing work on the project.
 - A. If any single variable falls outside the tolerance listed on the mix design and/or the specifications on:
 1. Two consecutive reports following similar problems as outlined under section 1 of the Resolution Procedures.
 2. Three consecutive reports.
 - B. If any single variable falls outside of the gradation wide band tolerance on the mix design and/or the specifications on:
 1. Any single report following similar problems as outlined under section 1 of the Resolution Procedures.
 2. Two consecutive reports.
 3. If all procedures listed above have been exhausted and problems continue to occur and/or are not remedied in the manner or time agreed upon;
 - a. For Contract Work - the contractor will be put on notice of intent to terminate the contract. If the contractor does not remedy all the problems identified in the notice of intent to terminate within the time period stated in that notice, the City shall pursue termination of the contract in compliance with the applicable surety guidelines.
 - b. For Subdivision Work - the contractor will be required to stop work and schedule a meeting with the City Engineer, Planning Director and Director of Development Services to deliberate cancellation of the construction permit.

120.23 REFUND/PAYMENT TO THE CITY FOR FAILED ASPHALT DENSITIES

Tests on asphalt densities shall be averaged per lot. A reduction in price or refund/payment to the City will be made as follows:

PERCENT OF LABORATORY DENSITY	REFUND TO BE PAID
96% and up	NONE
95.0 to 95.9	1.20/SY
94.0 to 94.9	1.45/SY
93.0 to 93.9	1.75/SY
less than 93.0	Remove and replace or refund \$3.00/SY if the City Engineer feels the performance will be acceptable.

The payment will be made to the City of Las Cruces in the following manner: For work contracted by the City of Las Cruces, the payment will be withheld from payments due to the contractor. For subdivisions and other private work, the payment will be made to the City of Las Cruces by the Contractor who performed (the work) under the applicable permit.

120.30 FREQUENCY OF CONCRETE TESTS

1. Samples shall be taken to represent every 50 cubic yards or fraction thereof per day.
2. A battery of tests on the concrete samples shall consist of a minimum of one each of the following procedures:
 - A. Concrete Cylinders (minimum 3 per set)
 - B. Slump
 - C. Air content
 - D. Temperature
3. Concrete tests are not required on pours less than 3 cubic yards but may be taken if the City's Inspector chooses.

120.31 CONCRETE ACCEPTANCE LOTS

1. A lot shall be defined for each use of concrete as indicated below:
 - a. Flatwork - every 50 cubic yards unless otherwise specified. A single set of cylinders shall represent the entire pour for a given day at a given site if less than 50 cubic yards. If pour is more than 50 cubic yards a single set of cylinders shall represent the equivalent lineal foot representation of the 50 cubic yards in question.
 - b. Footings - every 24 cubic yards or fraction thereof per half day. A single set of cylinders shall represent the entire pour for a given day at a given site if less than 24 cubic yards. If pour is more than 24 cubic yards a single set of cylinders shall represent the equivalent lineal foot representation of the 24 cubic yards in question.
 - c. Structures - every 50 cubic yards unless otherwise specified. A single set of cylinders shall represent the entire pour for a given day at a given site if less than 50 cubic yards. If pour is horizontal and more than 50 cubic yards a single set of cylinders shall represent the equivalent square foot area covered by the 50 cubic yards in question. If pour is vertical and more than 50 cubic yards a single set of cylinders shall represent 500 lineal foot of wall per lift as defined in Section 505.25 Item 6.
2. Tests on all variables except strength will only be given tolerances as outlined in the job mix formula and/or the specifications. If the material does not meet the requirements under sections 2B, 2C, or 2D of Section 120.60, it shall be rejected at the job site. (If air content is too low, air entraining agents may be added)
3. If the 28 day compressive strength of any test is lower than that specified, then reference shall be made to ASTM C-94 wherein an average compressive strength can be determined. If the resultant average 28 day compressive strength is equal to or greater than the specified strength, the concrete will be accepted and paid for at the full price. If the resultant average 28 day compressive strength is less than the specified strength, an equitable refund shall be made to the City of Las Cruces for the affected work as shown in section 120.80.
4. Windsor probe will not be used to determine strength for purposes of acceptance.
5. Coring may be done in compliance with ASTM procedures if the Contractor feels Cylinder breaks are not representative of the actual strength of the concrete in the field. However, the cost of coring shall be borne by the contractor or applicable subcontractors and the frequency of the coring shall be taken at the same frequency as the cylinders.

120.32 FREQUENCY OF MORTAR TESTING

1. Samples shall be taken to represent every cubic yard or fraction thereof per half day.
2. A battery of tests on the mortar samples shall consist of a minimum of one each of the following procedures:
 - A. Sampling and creating cubes (minimum 2 per set)
 - B. Compressive strength test of mortar cubes.

120.33 MORTAR ACCEPTANCE LOTS

1. A lot for rock walls shall be defined as every three (3) cubic yards of mortar mixed or a fraction thereof per half day. A single set of mortar cubes shall represent the entire pour for a given half day at a given site if less than three (3) cubic yards of mortar mixed. If pour is more than three (3) cubic yards of mixed mortar a single set of mortar cubes shall represent 100 lineal foot of wall per vertical foot. Contractors are urged to supplement these tests with additional tests if they want additional cylinders to represent the pour.
2. A lot for drainage structures shall be defined as every three (3) cubic yards of mortar mixed or a fraction thereof per half day. A single set of mortar cubes shall represent the entire pour for a given half day at a given site if less than three (3) cubic yards. If pour is more than three (3) cubic yards of mixed mortar a single set of mortar cubes shall represent 50 square feet of drainage floor per vertical foot.

120.34 REFUND/PAYMENT TO THE CITY FOR LOW STRENGTH CONCRETE

1. A refund/payment will be made to the City of Las Cruces as shown on in the following table based on the average 28 day compressive strength as determined by ASTM C94 averages.

REFUND/PAYMENT TO BE PAID - CONCRETE

TYPE OF WORK	SPECIFIED STRENGTH OR ABOVE	1-500 PSI BELOW SPECIFIED STRENGTH	MORE THAN 500 PSI BELOW SPECIFIED STRENGTH
CURB AND GUTTER (ANY TYPE)	NONE	\$1.50/LF	REMOVE AND REPLACE
4" CONCRETE SLAB OR SIDEWALK	NONE	\$0.40/SF	REMOVE AND REPLACE
6" CONCRETE SLAB, SIDEWALK, OR DRIVEPAD	NONE	\$0.60/SF	REMOVE AND REPLACE
6" REINFORCED CONCRETE	NONE	\$0.80/SF	REMOVE AND REPLACE
HYDRAULIC AND OTHER STRUCTURES (ie: drop inlets, culverts, manholes, utility access covers, etc..)	NONE	\$25.00/CY OF CONCRETE USED	REMOVE AND REPLACE
CONCRETE FOOTINGS (non-retaining)	NONE	\$3.00/LF	REMOVE AND REPLACE
CONCRETE FOOTINGS(retaining)	NONE	REMOVE AND REPLACE	REMOVE AND REPLACE
MORTAR (hydraulic structures)	NONE	\$1.50/LF	REMOVE AND REPLACE
MORTAR (non- retaining rock wall)	NONE	\$2.00/LF	REMOVE AND REPLACE
MORTAR (retaining structures)	NONE	REMOVE AND REPLACE	REMOVE AND REPLACE

The payment will be made to the City of Las Cruces in the following manner: For work contracted by the City of Las Cruces, the credit will be withheld from payments due to the contractor. For subdivisions and other private work, the payment will be made to the City of Las Cruces by the Contractor who performed (the work) under the applicable permit.

120.40 FREQUENCY OF DENSITY TESTING

1. The following are minimum density testing requirements for street construction. Additional testing as required by field conditions may be requested by the Engineer.

A.	Street Subgrade Density	1 Per 150 lf
B.	Street Base Course Density	1 Per 125 lf
C.	Base Course Gradation	1 Per 300 lf
D.	Sidewalk Base or Subgrade Density	1 Per 200 lf
E.	Curb & Gutter Base or Subgrade Density	1 Per 125 lf
F.	Drivepad Base or Subgrade Density	1 Per 90 lf
G.	Manhole Base or Subgrade Density	1 Per location
H.	Street/Signal Light Bases	1 Per location

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SECTION 125 TRAFFIC CONTROL

125.00 SCOPE

This section covers traffic control requirements for road construction or maintenance work occurring within the Public Right of Way within the corporate limits of the City of Las Cruces.

125.10 APPROVAL

A Traffic Control Plan must be submitted to the Traffic Engineering Department through the Project Engineer for approval prior to proceeding with any construction or maintenance activities within the City Right of Way.

125.20 REFERENCES

All Traffic Control utilized within the Public Right of Way shall conform to the latest edition of the **Manual of Uniform Traffic Control Devices (MUTCD)**.

Traffic Control requirements shall also conform to all applicable sections of the latest edition of the **City of Las Cruces General Conditions for Construction Contracts**.

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SECTION 200

EXCAVATION, SITE AND SUBGRADE PREPARATION

200.00 SCOPE

The work covered by this section of the specifications consists in furnishing all plant, labor, equipment, supplies, and materials, and in performing all operations in connection with the excavations, including borrow; excavation for structures and ditches; construction of embankments, shoulders, and gutters; preparation of subgrade including spot reinforcement; and grading, including all hauling, wetting, rolling, and other operations pertaining thereto, complete. Excavation, trenching, and backfilling for utilities, including excavation and backfilling for manholes and other structures.

200.01 DEFINITIONS

- A. General Excavation. General excavation consists of excavating and grading; excavating all unsuitable material, regardless of character, including, but not limited to: existing bituminous surfacing, curb and gutter, sidewalk, miscellaneous structures, etc., from the subgrade; and disposing of all excavated materials, as specified and in conformity with the lines, grades, cross sections, and dimensions shown or indicated on the drawings. General excavation shall include any excavation or grading along the street or roadway, including areas in back of curbs, other than excavation from borrow areas, required to produce in place, complete, the materials necessary for embankments and fills, and to replace unsatisfactory materials from other excavation or grading operation.
- B. Borrow. This item consists of excavating approved suitable material as determined by the Engineer from borrow pits or areas selected by the Contractor.
- C. Excavation for Drainage Structures. This item consists of the necessary excavation for pipe, culverts, improvements of banks for water channelization and diversion, and all other drainage structures for which foundation excavation is not otherwise provided under the individual items, including the disposal of all excavated material and all necessary bailing, diversions and drainage.
- D. Embankment. This item consists of placing in embankments, in miscellaneous backfills, and behind curbs and gutters, including the backfills around drainage and other structures, the materials excavated under the items excavation and borrow, all in accordance with the specified requirements and in conformity with the lines, grades, cross sections, and dimensions shown on the drawings.
- E. Subgrade Preparation. This item consists of the dressing, scarifying, shaping, wetting, and compacting, as required, of the subgrades to the full width of the roadbed, under curb and gutter, sidewalks, culverts and storm drain pipe, and any additional requirements herein in accordance with the specified requirements, and in conformity with the lines, grades, and cross sections shown on the drawings.
- F. Ditches. The term ditches shall be interpreted to mean all side ditches, diversion ditches, changes in channels or streams, inlet and outlet ditches to and from culverts and other structures, and outlet and

other ditches in connection with surface drainage.

G. Compaction. Except as otherwise specified, the degree of compaction for backfill, embankment, and subgrade shall be based on AASHTO Standard Method of Test T 180 (ASTM Designation D 1557), Moisture-Density Relations using a ten pound (10 lb) Ram and an eighteen inch (18") Drop. Conformance to compaction requirements, as specified by a percentage of the maximum density determined by AASHTO Standard Method of Test T 180 (ASTM Standard Method D 1557), shall be determined by field tests conducted in accordance with one of the following test procedures:

1. AASHTO Standard Method of Test T 191 (ASTM Designation D 1556) Density of Soil In-Place by the Sand-Cone Method.
2. AASHTO Standard Method of Test T 238 (ASTM Designation D 2922), Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
3. AASHTO Standard Method of Test T 239 (ASTM Designation D 3017), Moisture Content of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
4. AASHTO Standard Method of Test T 205 (ASTM Designation D 2167), Density of Soil In-Place by the Rubber-Balloon Method.

H. Moisture Content. The moisture content of subgrade or embankment material, at the time of compaction, shall be optimum moisture content plus or minus two percent ($\pm 2.0\%$), except in high volume-change soils. The Engineer may require a moisture content in excess of optimum in such high volume-change soils. Subgrade or embankment materials, except as herein provided, containing moisture in excess of optimum shall be dried to the required moisture content. Subgrade or embankment material that does not contain sufficient moisture to compact to the required density shall be uniformly watered and mixed as required.

200.02 EXCAVATION

There will be no classification of excavated materials and the term "excavation" shall comprise and include the satisfactory removal and disposition or utilization of all materials excavated regardless of the nature of the materials encountered, the condition of the material at the time it is excavated, the location of the material excavated, or the manner in which it is excavated.

200.03 CONSERVING TOP SOIL AND SELECT MATERIAL

During the progress of excavation, material taken from the cuts and deemed suitable for topping and subgrade material or road finishing shall be saved and utilized for these purposes as directed by the Engineer. When practicable, selected material shall be hauled directly from excavation to final position on the roadbed.

If handling the selected material directly from excavation to its final position at the time is impracticable, selected material shall remain in place until it can be placed in final position on the roadbed, or, if specifically ordered by the Engineer, selected material shall be excavated, piled at locations designated by the Engineer, and later placed on the roadbed.

200.04 UTILIZATION OF EXCAVATED MATERIALS

All suitable material removed from the excavations shall be used, insofar as practicable, in the formation of embankments, subgrades, shoulders, slopes, bedding, backfill for culverts and other structures, and for such other purposes as directed by the Engineer.

200.05 SELECTION OF BORROW MATERIAL

Borrow material shall be selected to meet the requirements and conditions for the particular embankment or backfill for which it is to be used. Borrow material shall be obtained from sources selected by the Contractor.

200.06 EXCAVATION FOR STRUCTURES

Excavation shall be done to the lines, grades, and elevations shown on the drawings. Trenches and pits shall be of sufficient size to permit the placing and removal of forms for the full width and length of structure footings and foundations. Bracing, sheeting, and shoring shall be provided as necessary to protect against earth or structure failures. Any obstacles, except service lines, encountered in excavations shall be removed within the lines of excavations. Any existing service lines encountered shall be supported and protected from damage.

200.07 BACKFILLING FOR STRUCTURES

A minimum of seven (7) days curing of concrete will be required before backfilling around any new concrete structure. After the structure has been completed, selected material from excavation or borrow, at a moisture content which will facilitate compaction, shall be placed alongside the structure in layers not exceeding six inches (6") loose in depth where hand, mechanical tamping or compaction by vibratory type compactors is employed, or eight (8) to twelve inches (12") loose where the material is to be rolled. Symmetrical backfill loading shall be maintained. Special care shall be taken to prevent any wedging action or eccentric loading upon or against the structure. Each layer shall be thoroughly compacted by rolling or tamping with mechanical rammers. This method of filling and compacting shall be continued until the backfilling is complete. Tests for density of compaction will be made at the option of the Engineer, and deficiencies shall be corrected by the Contractor without additional cost to the Owner.

The operation of heavy equipment shall be conducted so that no damage to the structures will result. Where it is necessary, in the opinion of the Engineer, sheeting and/or portions of the bracing shall be left in place. Backfill around and adjacent to all structures shall be compacted to a minimum density of ninety-five percent (95%) as determined by the AASHTO Standard Method T 180. The top twelve inches (12") under base course and curb-and-gutter shall be compacted as hereinafter provided for subgrade preparation.

For structures constructed in advance of fills, the fill material adjacent to the pipe and structures and the compaction requirements shall be as specified above. The fill material shall be uniformly spread in layers around the structure, 6 inches in depth where hand or mechanical tamping is employed or eight (8) to twelve inches (12") where compaction is secured by rolling longitudinally with the structure.

200.08 EXISTING SERVICE LINES AND UTILITY STRUCTURES

All existing service lines and utility structures uncovered or encountered during all classes of excavation, including borrow, and during all operations incident to all grading work, construction of embankments, and backfilling shall be safeguarded and protected from damage, and supported, if necessary, as specified or indicated on the drawings, or as directed by the Engineer.

200.09 PREPARING GROUND SURFACE FOR EMBANKMENTS

After the right-of-way is cleared, of all rubbish, vegetation, and man-made structures, and all utilities have been installed, adjusted, or removed, the total width upon which fill is to be made and upon which equipment can be used shall be loosened by plowing or scarifying so the surface will be broken to a depth of six inches (6") and shall be wetted and compacted as follows:

- A. Ninety-five percent (95%) of maximum density, as determined by AASHTO Standard Method of Test T 180 (ASTM Designation D 1557) for material having less than thirty-five percent (35%) passing the No. 200 sieve.
- B. Ninety percent (90%) of maximum density as determined by AASHTO Standard Method of Test T 180 (ASTM Designation D 1557) for materials having thirty-five percent (35%) or more passing a No. 200 sieve as approved by the Engineer.

200.10 FORMATION OF EMBANKMENTS

Embankments shall be formed of approved material, placed in horizontal layers. Materials shall be placed in successive layers of not more than twelve inches (12") in loose depth. Each layer shall be spread uniformly and rolled with an approved tamping or pneumatic roller until thoroughly compacted to ninety-five percent (95%) of maximum density obtained at optimum moisture content, except for the subgrade as hereinafter provided. Where rock is to be incorporated in fills or portions of fills composed largely of earth or friable materials, the rock shall be reduced to six-inch (6") maximum size.

200.11 SUBGRADE PREPARATION

All soft and unstable material and other portions of the subgrade which will not compact readily or serve the intended purpose shall be removed and replaced with suitable material from excavation or borrow or suitable materials shall be added and, by manipulation, be incorporated into the subgrade to produce a material meeting subgrade requirements.

After the subgrade has been shaped to approximate line, grade, and cross section, the entire roadbed shall be loosened by harrowing or scarifying the material and shall be brought to proper moisture content and compacted in eight-inch (8") loose lifts in compliance with paving design. The subgrade shall be thoroughly compacted to ninety-five percent (95%) of maximum density obtained at optimum moisture content, as described under section 200.9, parts A and B.

200.12 SITE PREPARATION

- A. General. This work shall include removal and disposal of all materials in clearing and grubbing, and removal of structures and obstructions. Site preparation shall include removal and disposal of all materials of whatever nature and the filling required to restore the earth to the natural ground or subgrade level in accordance with the applicable provisions of these specifications. All material removed in site preparation work, including earth, if not required for subsequent fill operations, shall be removed from the site and disposed of. Salvageable material shall be delivered to storage where directed if such material is desired by the City. Material to be re-used and replaced shall be salvaged and kept in good condition prior to re-installation. Otherwise, such material shall become the property of the Contractor and removed from the site.

The Contractor shall satisfy himself by field inspection as to the removal and disposal required. The plans may show existing improvements to be removed and disposed of, but may not include all the work which may be revealed by a detailed field investigation by the Contractor. The physical obstructions, including trees and shrubs, will be shown on the plans as completely as possible, using field notes and aerial photographs. However, any physical obstructions not shown on the plans shall be removed under general site preparation whether shown on the plans or not. Service lines may not be shown, but such removals and plugging as hereinafter described shall be accomplished as a part of general site preparation.

- B. Clearing and Grubbing. Clearing and grubbing shall consist of clearing areas between right-of-way lines of all trees, snags, stumps, limbs, bushes, roots, debris, and all other such objectionable material, and shall include grubbing stumps and roots, and the disposal of all spoil material resulting from such clearing and grubbing, as herein provided. All stumps and roots larger than two inches (2") in diameter shall be removed to a depth of not less than twelve (12") below the finished subgrade level or natural ground.
- C. Removal and Disposal of Structures. This work shall consist of the removal and disposal of structures or portions of structures not indicated on the plans to be removed by others. Houses or parts of houses not called for on the plans to be removed by others, within the right-of-way lines, as well as all concrete foundations, including basements and footings, shall be removed. Any earth fill necessary to reach final grades shall be installed in accordance with the applicable provisions of this section of the specifications. Other miscellaneous structures shall be removed unless called for on the plans to be removed by others.
- D. Removal and Disposal of Obstructions. This work shall consist of the removal and disposal of fences, walls, pavement, curbs and gutters, sidewalks, concrete medians, abandoned utility facilities including service lines, pipe lines, sewer lines, manholes, and other obstructions shown on the plans or otherwise provided in these specifications. All obstructions within the limits of right-of-way, except operating utility facilities, pipe lines, sewers, and appurtenances and obstructions indicated on the plans to be removed by others, shall be removed and disposed of by the Contractor.

All sewer service lines within the limits of right-of-way lines shall be removed by the Contractor to a minimum of two feet (2') below subgrade level, finished grade, or natural ground, and shall

be cut at the main line and plugged with clay disk and concrete. Water service lines will be cut and plugged at the mains and meters will be removed by the City at City's expense after the Contractor removes curb and gutter, sidewalk, and paving. The Contractor shall coordinate his work with the City in removal of these concrete and paving items. Gas service lines will be cut and plugged at the gas mains by the City Utilities Department. The Contractor shall remove all abandoned water and gas service lines to two feet (2') below subgrade level, finished grade, or natural ground.

The Contractor shall comply with City Ordinance 1231, approved by the City Council on May 6, 1991, which states that all removals shall be disposed of at a "permitted sanitary landfill".

- E. Maintenance. After City Inspectors test and approve a subgrade, the contractor shall be required to maintain the subgrade in good condition, at the required density, and within $\pm 2.0\%$ of optimum moisture. The subgrade surface shall be finished and maintained to ± 0.1 foot of plan design elevations until a surface course is applied.

200.13 MEDIAN GRADING

Median grading, including compacted fill, shall be constructed as called for on the drawings.

SECTION 205

TRENCH EXCAVATION AND BACKFILL

205.00 GENERAL

→ see 200.02

This work shall consist of excavation of the trench and the backfilling of the trench for all pipelines, cables, conduits, and appurtenances, in total compliance with the specifications and drawings such that the completed work is of a first class, complete and workmanlike nature.

From the State Highway's viewpoint and from the City's viewpoint, the essential features for open trench construction are:

- A. Trench construction techniques comply with Occupational Safety Hazards Act (OSHA) safety requirements for the protection of the public and the employees of the Contractor and the owner.
- B. Restoration of the structural integrity of the roadbed.
- C. Security of the pipe against deformation.
- D. Assurance that the trench does not become a drainage channel, nor that the backfill blocks roadway drainage.

Trenching and backfilling shall conform to the requirements of the New Mexico Underground Property Damage Law.

The Contractor shall call "Blue Stake" for underground utility locates prior to beginning excavation operations.

205.10 EXCAVATION AND BACKFILL

- A. The Contractor shall perform excavation of whatever substance encountered to the depths indicated on the drawings or specified herein. Any excavation beyond the authorized depths shall be filled with suitable compacted material at the Contractor's expense. All excavations shall be made by open cut except where boring, jacking, or tunneling is specified.
- B. The Contractor shall make himself aware of current OSHA requirements concerning trenching and shall perform his work accordingly. If the trench width varies and requires extra bedding, the Contractor shall provide it at his own expense unless otherwise stated in the contract. The banks (sides) of all trenches shall be kept as nearly vertical as practicable and where required to protect adjacent structures and to safeguard employees, shall be properly sheeted and braced. The shape and size of all trench cross sections shall conform to current OSHA trenching requirements.
- C. All grading in the vicinity of trench excavations shall be controlled to prevent surface water from flowing into the trenches or damaging other property. Any water accumulated in the trenches

shall be removed by pumping or by other approved method.

Should the trench bottom become unstable from the entrance of surface water into the open excavation, the saturated soil shall be removed and suitable backfill placed and compacted to grade at no additional cost to the owner.

- D. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner. Materials unsuitable for backfilling shall be wasted in a suitable location. Where material is excavated from a trench and piled adjacent to the trench that material shall be piled in such a way that the toe of the slope of the material is at least two feet (2') from the edge of the trench.
- E. Trench depth shall be sufficient to permit sewer pipe installation at the design grade and elevation. Other pipelines, cables and conduits shall be installed at the specified cover or as shown on the Detail Drawings.

Extra trench depth shall be provided as designated herein or on the Drawings at arroyo crossings, streets, and roadways, and where necessary to provide adequate clearance under ditches, culverts or other structures. The Utilities Department, when necessary, shall determine in the field the locations and additional trench depths required.

- F. Should any rock, coarse stone, boulders, or other materials be encountered which would prevent the obtainment of suitable bedding, the trench shall be excavated to at least six inches (6") extra depth and backfilled to grade with properly compacted suitable material.
- G. Backfill of all trenches shall be performed by carefully placing suitable loose earth on both sides of and above the pipe and compacting to the required density up to a point at least twelve inches (12") above the top of the pipe. The backfill material placed within twelve inches (12") of the pipe shall contain no rocks or objectionable materials which might damage the pipe or coating. Also, the backfill and bedding material shall conform with the pipe or coating manufacturer's recommended soil type. The remainder of the backfill material shall be placed in lifts not to exceed twelve inches (12") of loose material and compacted to the density required.
- H. Flowable fill may be used in shallow, narrow trench excavations. Materials shall conform to Section 515, FLOWABLE FILL. Use of flowable fill in large volumes is discouraged in areas of collapse prone soils and expansive soils that are moisture sensitive and in areas of large excavations.

205.20 ROCK EXCAVATION

Blasting. No blasting shall be done within one hundred feet (100') of any existing gas lines. Blasting shall not take place unless written approval has been obtained from the City and other proper authorities and is done in a legal and completely safe manner.

205.30 COMPACTION METHODS

Compaction methods and equipment may utilize hand and mechanical tampers, rollers, and flooding. The equipment and procedures proposed by the Contractor shall be subject to the approval of the Utilities Division. The use of "Hydro-Hammers" will not be allowed. Extreme care shall be taken by the Contractor when flooding to prevent any floating of the pipeline from its proper location at the specified depth and to prevent cave-ins.

205.40 COMPACTION DENSITY REQUIREMENTS

- A. All trench backfill within City or County road and street rights-of-way, shall be compacted to ninety-five percent (95%) of the Modified Proctor Maximum Density at a moisture content within plus or minus two percent ($\pm 2\%$) of optimum. Backfill material having thirty-five percent (35%) or more passing the #200 sieve shall be compacted to ninety percent (90%) of the Modified Proctor Maximum Density, at a moisture content within plus or minus two percent ($\pm 2\%$) of optimum.
- B. State Highway right-of-way within the immediate shoulder, will be compacted to ninety-five percent (95%) of Modified Proctor Maximum Density.
- C. Backfill outside the above described areas will be compacted to ninety percent (90%) of maximum density, per the Modified Proctor Method.

205.50 DENSITY TEST MINIMUM FREQUENCY

- A. Horizontally.
 - 1. One for every 300 LF on mains or any part thereof per day;
 - 2. One per every three services or any part thereof per day.
- B. Vertically.
 - 1. Four feet (4') or less in depth - One at 1/2 depth and one at subgrade;
 - 2. Greater than four feet (4') in depth - One for six inch (6") or larger pipe, then one for every three (3) vertical feet and one at subgrade.

205.60 DENSITY TESTS - COSTS

The cost of retesting failed density tests shall be paid for by the Utility Contractor. A copy of all test results shall be submitted to the City by the testing lab prior to the acceptance of the utility project by the Utilities Division.

205.70 ASPHALTIC PAVEMENT REPLACEMENT

- A. Description. This work shall consist of the replacement of asphaltic pavement removed for the construction of utilities.
- B. Contractor's Obligations. The contractor will be expected to replace all pavement removed during construction in compliance with this document unless otherwise specified by the City Utilities Division.
- C. Materials and Construction Requirements. Replacement of asphaltic pavement shall conform to the requirements of Section 355, PATCHING OF ASPHALT PAVEMENTS.
- D. Disposal of Materials. The Contractor shall comply with City Ordinance 1231, approved by the City Council on May 6, 1991, which states that all removals shall be disposed of at a "permitted sanitary landfill".

SECTION 210

GRADED GRAVEL BASE COURSE

210.10 SCOPE

The work covered by this section of the specifications consists of furnishing labor, equipment, and materials, and in performing all operations in connection with the complete construction of a graded gravel base course on a prepared subgrade, complete.

210.20 GENERAL

This item shall consist of furnishing base course aggregate, hauling, spreading, compacting and finishing such materials in conformity with the grade, dimensions, and typical sections shown on the plans or as directed by the Engineer.

210.30 MATERIAL

Base course aggregate shall be well graded. The percentage composition by weight shall be within the following limits:

SCREEN AND SIEVE SIZES	PERCENT PASSING
1 1/2"	100%
3/4"	85 - 100%
No. 4	35 - 65%
No. 10	25 - 50%
No. 200	4 - 12%

510
 29100 13.7
 12.9
 13.3
 13.7
 - P.I. = 7
 - L.L. = 27

210.40 ROCK, GRAVEL, AND RECLAIMED CONCRETE

Rock, gravel, or reclaimed concrete shall be clean, hard, sound, durable, uniform in quality, and free of any detrimental quantity of soft, friable, thick, elongated or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.

The loss by abrasion as determined by AASHTO T 96, "Resistance to Abrasion of Small Size Coarse Aggregate by Use of The Los Angeles Machine," shall not exceed forty percent (40%) by weight after five hundred (500) revolutions. The P.I. shall be five (5) or less and the liquid limit shall be twenty-five (25) or less. The soundness as determined by AASHTO T 104, "Soundness of Aggregate by Use of Magnesium Sulfate," shall be eighteen (18) or less.

The portion of the materials retained on a No. 4 screen shall contain at least fifty percent (50%) by weight of particles having at least two (2) fractured faces as defined by ASTM D-8 and not over five percent (5%) shall be pieces that show no such faces.

210.50 CONSTRUCTION METHODS

- A. Subgrade. Immediately prior to the placing of the graded gravel base course, the subgrade shall be brought to a uniform line and grade as specified in the Grading Section of these specifications. The subgrade upon which the graded gravel base is to be placed shall be cleaned and free from frozen material.
- B. Depth. The minimum depth of graded gravel base course shall be six (6) inches throughout the specified area unless otherwise specified by the Engineer. The finished surface of the base shall not show any deviation in excess of three sixteenths of an inch (3/16") when tested with a ten foot (10') straightedge in any direction.
- C. Compaction. At the start of compaction, the percentage of moisture in the mixture shall be plus or minus two percent ($\pm 2\%$) of optimum moisture.
- D. Density. Density of base course shall be determined by AASHTO Standard Method of Test T 180 (ASTM Designation D 1557), Moisture Density Relations using a ten pound (10 lb) Ram and an eighteen inch (18") Drop. Unless otherwise provided, the base shall be compacted to not less than ninety-five percent (95%) of maximum density. Field densities shall be determined by one of the following methods:
1. AASHTO Standard Method of Test T 191 (ASTM Designation D 1556), Density of Soil In-Place by the Sand Cone Method.
 2. AASHTO Standard Method of Test T 238 (ASTM Designation D 2922) Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
 3. AASHTO Standard Method of Test T 239 (ASTM Designation D 3017), Moisture Content of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
 4. AASHTO Standard Method of Test T 205 (ASTM Designation D 2167), Density of Soil In-Place by Rubber-Balloon Method.
- E. Maintenance. The Contractor shall be required, within the limits of his contract, to maintain the base in good condition until all work has been completed and accepted.

SECTION 215

GRADED GRAVEL BASE COURSE

(FOR ROADS THAT WILL NOT BE IMMEDIATELY PAVED)

215.00 SCOPE

The work covered by this Specification consists of furnishing all plant, labor, equipment and materials, and in performing all operations in connection with the complete construction of a graded gravel base course on a prepared subgrade.

215.10 GENERAL

This item shall consist of furnishing base course aggregate, hauling, spreading, compacting, and finishing such materials in conformity with the grade, dimensions, and typical sections shown on the plans or as directed by the Engineer.

215.20 MATERIALS

Base course aggregate shall be well graded. The percentage composition by weight shall be within the following limits:

SCREEN AND SIEVE SIZES	% PASSING
1 1/2"	100%
3/4"	85 - 100%
No. 4	35 - 70%
No. 10	25 - 60%
No. 200	4 - 20%

215.30 ROCK, GRAVEL AND RECLAIMED CONCRETE

- A. Rock, gravel, or reclaimed concrete shall be clean, hard, sound, durable, uniform in quality, and free of any detrimental quantity of soft, friable, thick, elongated or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.
- B. The loss by abrasion as determined by AASHTO T 96, "Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine," shall not exceed forty percent (40%) by weight after five hundred (500) revolutions. The soundness as determined by AASHTO T 104, "Soundness of Aggregate by Use of Magnesium Sulfate," shall be eighteen (18) or less.
- C. The portion of the materials retained on a No. 4 screen shall contain at least fifty percent (50%) by weight of particles having at least two (2) fractured faces as defined by ASTM D-8 and not over five percent (5%) shall be pieces that show no such faces.

- D. In addition to the above requirements, the graded gravel base course shall have a minimum liquid limit of twenty-five (25), a maximum of forty (40), and a minimum plastic index of eight (8), a maximum of fifteen (15). These requirements will apply for all roadways that will not be paved upon completion.

215.40 CONSTRUCTION METHODS

- A. Subgrade. Immediately prior to the placing of the graded gravel base course, the subgrade shall be brought to a uniform line and grade. The subgrade upon which the graded gravel base is to be placed shall be cleaned and free from frozen material.
- B. Depth. The minimum depth of graded gravel base course shall be six (6) inches throughout the specified area unless otherwise specified by the Engineer. The finished surface of the base shall not show any deviation in excess of one-quarter inch (1/4") when tested with a ten foot (10') straightedge in any direction.
- C. Compaction. At the start of compaction, the percentage of moisture in the mixture shall be plus or minus two percent ($\pm 2\%$) of optimum moisture.
- D. Density. Density of base course shall be determined by AASHTO Standard Method of Test T 180 (ASTM Designation D 1557), Moisture Density Relations using a ten pound (10 lb) weight Ram and an eighteen inch (18") Drop. Unless otherwise provided, the base shall be compacted to not less than ninety-five percent (95%) of maximum density. Field densities shall be determined by one of the following methods:
1. AASHTO Standard Method of Test T 191 (ASTM Designation D 1556), Density of Soil In-Place by the Sand Cone Method.
 2. AASHTO Standard Method of Test T 238 (ASTM Designation D 2922), Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
 3. AASHTO Standard Method of Test T 239 (ASTM Designation D 3017), Moisture Content of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
 4. AASHTO Standard Method of Test T 205 (ASTM Designation D 2167), Density of Soil In-Place by Rubber-Balloon Method.
- E. Maintenance. The Contractor shall be required, within the limits of his/her Contract, to maintain the base in good condition until all work has been completed and accepted.

SECTION 220

ASPHALT TREATED BASE

220.00 DESCRIPTION

This work shall consist of base course aggregate and bituminous material mixed in a central plant and spread and compacted on a prepared surface in substantial compliance with the specifications, lines, grades, thicknesses, and typical cross-sections shown on the plans.

220.10 MATERIALS

- A. Bituminous Material. The bituminous material shall conform to the requirements of Section 405 (High Float Emulsion).
- B. Aggregate. Base course aggregate shall conform with the requirements of Section 210, as well as Section 220.30 item C.

220.20 PROPORTIONING

The aggregate selected for use in the work shall have a gradation within the limits designated in B. above, preferably close to the center of the band, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but shall be uniformly graded from coarse to fine.

Bituminous material shall be of type designated in A. above and shall be 4.0% by total weight of mix.

- 1. AASHTO Standard Method of Test T 164 (ASTM Designation D 2172) Quantitative Extraction of Bitumen.

The job-mix formula, will be allowed the following tolerances:

Asphalt	± 1.0 percent
Temperature of mix at delivery	± 25.0 degrees F

220.30 CONSTRUCTION METHODS

- A. Subgrade. Immediately prior to the placing of the Asphalt Treated Base, the subgrade shall be brought to a uniform line and grade as specified in the Grading Section of these specifications. The subgrade upon which this base is to be placed shall be cleaned and free from frozen material.
- B. Depth. The minimum depth of Asphalt Treated Base shall be Four inches (4"/102 mm) throughout the specified area unless otherwise specified by the Engineer. The finished surface of the Asphalt Treated Base shall not show any deviation in excess of one-quarter inch (1/2"/12.8 mm) when tested with a ten foot (10'/3 m) straightedge in any direction.
- C. Density. Unless otherwise provided, the Asphalt Treated Base shall be compacted to not less than

ninety five percent (95%) of maximum density. Field densities shall be determined by one of the following methods:

1. AASHTO Standard Method of Test T 238 (ASTM Designation D 2922) Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
 2. AASHTO Standard Method of Test T 239 (ASTM Designation D 3017), Moisture Content of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
- D. Maintenance. The Contractor shall be required, within the limits of his contract, to maintain the base in good condition until all work has been completed and accepted.

SECTION 225

RIPRAP

225.00 GENERAL

This specification shall be used for the installation of stone to be used as dumped riprap, grouted riprap, wire-tied riprap, french drain stone, or gabion stone; and the installation of wire fabric for wire-tied riprap.

225.10 STONE

All stone must be sound and Durable, free from seams and coatings, and of such characteristics that it will not disintegrate when exposed to the actions of flowing water. The riprap rock shall meet the following requirements:

1. A specific gravity of at least 2.50, as determined by ASTM C-127.
2. A Los Angeles abrasion wear of not more than 50 % as determined by AASHTO T 96.
3. Soundness Loss of not more than 21 %, as determined by AASHTO T 104.
4. Freeze-Thaw loss of not more than 10 % loss after 12 cycles, in compliance with AASHTO T 103, Procedure A.
5. The size and gradation of the riprap stone shall be as follows:

RIPRAP DESIGNATION	% SMALLER THAN OR EQUAL TO THE GIVEN SIZE BY WEIGHT.	MINIMUM DIMENSION (INCHES)
TYPE VL (very light)	100	9"*
	35-55	6"
	10	2"
TYPE L (light)	100	12"*
	35-55	9"
	10	2"
TYPE M (medium)	100	18"*
	35-55	12"
	10	3"
TYPE H (heavy)	100	24"*
	35-55	18"
	10	6"

NOTE: At least 30% of all stones by weight shall be this dimension.

225.20 WIRE FABRIC

1. Wire fabric for riprap shall be double twisted hexagonal mesh conforming to the requirements of ASTM A975 and shall have a Class 3 zinc coating which conforms to ASTM A90.

2. Wire composing the mesh shall be 11 1/4 gage (0.118" in dia.) or larger. Mesh openings shall be uniform in size measuring not more than 4 3/4" in the largest dimension but must have at least one dimension of 3 1/4 or less.
3. Fasteners may be ties, hog rings, or lacing wire and shall conform to ASTM A764 for coating. Ties and hog rings shall be 9 gage (approx. 0.148" in dia.) or larger and lacing wire shall be 13 1/2 gage (approx. 0.092" in dia.) or larger.

225.30 STAKES

1. Steel stakes may be railroad rails weighing not less than 30 lbs. per lf, 4" O.D. standard strength galvanized steel pipe, or steel angles which are 4"x4"x3/8" in dimension.
2. Steel stakes shall be driven to project 6" above top of riprap, placed 8 foot on center beginning 2 feet from the top of the slope unless otherwise noted on the plans.

3. Fasteners may be ties, hog rings, or lacing wire and shall conform to ASTM A764 for coating. Ties

225.30 STAKES

1. Steel stakes may be railroad rails weighing not less than 30 lbs. per lf. 4" O.D. standard strength
2. Steel stakes shall be driven to project 6" above top of riprap, placed 8 foot on center beginning 2



SECTION 230 GRAVEL

230.00 GENERAL

This specification defines aggregate size designations and ranges in mechanical analysis for standard sizes of materials for use in the construction and maintenance of various types of roadways in compliance with ASTM D 448-86. For purposes of this specification, GRAVEL shall be defined as a crushed Engineering material.

230.10 MANUFACTURE

The standard sizes of aggregates described in this classification may be manufactured by means of any suitable process used to separate raw material into the desirable size ranges. However, a minimum of 40% of the material must be crushed rock with a minimum of two fractured faces.

230.20 CLASSIFICATION

The classification of the material shall be based on the size number and size ranges shown below with the material being sampled in compliance with ASTM D 75 and tested for grading using ASTM C 136.

230.30 GRADATION

Standard sizes of materials shall conform to the following table. Any other classification must be submitted to the Engineer prior to bid opening for determination of the acceptability of the material for the specific job at hand.

SIEVE SIZE	PERCENT PASSING	
	3/4" GRAVEL (ASTM D448 SIZE 6)	1" GRAVEL (ASTM D448 SIZE 5)
1.5"	----	100
1.0"	100	90-100
3/4"	90-100	20-55
1/2"	20-55	0-10
3/8"	0-15	0-5
No. 4	0-5	----

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SECTION 235

CRUSHER FINES

235.00 GENERAL

This specification defines aggregate size designations and ranges in mechanical analysis for standard sizes of materials for use in the construction and maintenance of various types of roadways in compliance with ASTM D 448-86.

For purposes of this specification, crusher fines shall be defined as a by-product or waste product from the production of Engineering materials.

235.10 MANUFACTURE

The standard sizes of aggregates described in this classification may be manufactured by means of any suitable process used to separate raw material into the desirable size ranges.

235.20 CLASSIFICATION

The classification of the material shall be based on the size number and size ranges shown below with the material being sampled in compliance with ASTM D 75 and tested for grading using ASTM C 136.

235.30 GRADATION

Standard sizes of materials shall conform to the following table. Any other classification must be submitted to the Engineer for determination of the acceptability of the material for the specific job at hand.

SIEVE SIZE	PERCENT PASSING
3/8"	100

Fines shall contain no more than 2% by weight of contaminants such as clay lumps and friable particles. Fines may be sampled and tested for contaminant in compliance with ASTM D75 and ASTM C142.

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SECTION 240 PLASTER SAND

240.00 SCOPE

This specification covers natural or manufactured aggregate for various uses. The material shall be produced and in conformance with ASTM C 897-88.

240.10 MATERIALS

Manufactured aggregate shall be specially processed to assure particle shape in addition to meeting the gradation contained herein.

240.20 COMPOSITION

The amount of deleterious substances in aggregates, each determined on independent samples (see Test Method C 40) complying with the grading requirements contained herein, shall not exceed the following:

ITEM	MAXIMUM PERMISSIBLE WEIGHT, %
FRIABLE PARTICLES	1.0%
LIGHT WEIGHT PARTICLES, FLOATING ON LIQUID HAVING A SPECIFIC GRAVITY OF 2.0	0.5%

240.30 PHYSICAL PROPERTIES

SOUNDNESS - shall conform to ASTM C 88. Except as herein provided, aggregate subjected to five cycles of the soundness test shall show a loss, when weighed in accordance with the grading of a sample complying with the limitations set forth in this document, not greater than 20% when Sodium Sulfate is used, or 15 % when Magnesium Sulfate is used.

240.40 GRADATIONS

1. The plaster sand shall be graded as follows:

U.S. STANDARD SIEVE	PERCENT PASSING
No. 4	100%
No. 8	90-100%
No. 16	60-90%
No. 30	35-70%
No. 50	10-30%
No. 100	0-5%

2. Not more than 50% shall be retained between any two sieves shown in the above table, nor more than 25% between No. 50 and No. 199 sieves. The amount of material finer than the No. 200 sieve shall not exceed 3%.
3. The fineness modulus shall fall between 2.05 and 3.05.

SECTION 300

BITUMINOUS PRIME COAT

300.00 DESCRIPTION

This work shall consist of an application of bituminous material on the completed base course and/or other approved material.

300.10 MATERIALS

Prime coat shall be composed of bituminous material of the type and grade specified on the plans or in the Contract. Bituminous materials shall be one of the following unless otherwise specified on the plans: MC-30, MC-70, SS-1, CSS-1 OR AEP. When approved by the Engineer, other emulsified asphalt may be used. Emulsified asphalt may be diluted by adding an equal amount of water (1 to 1) or as recommended by the manufacturer.

300.20 APPLICATION OF BITUMINOUS MATERIALS

Bituminous material shall be uniformly applied with a pressure distributor at a rate of 0.15 to 0.25 gallons per square yard (diluted), or as directed by the Engineer.

300.30 WEATHER LIMITATIONS

Shall meet the requirements of Section 340, BITUMINOUS PAVEMENT.

300.40 PENETRATION TIME

After the prime coat has been applied to the satisfaction of the Engineer, it shall be allowed to penetrate for a minimum period of 24 hours without being disturbed, or for such additional period of time necessary to permit adequate penetration.

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SECTION 305 BITUMINOUS TACK COAT

305.00 DESCRIPTION

This work shall consist of providing a bituminous material and applying it to an existing bituminous or portland cement concrete surface to increase the adherence of overlaid materials.

305.10 MATERIALS

Tack coat shall be composed of bituminous material of the type and grade specified on the plans or in the contract. Bituminous materials shall be one of the following grades unless otherwise specified on the plans: RS-1, HFE-100, HFMS-1, SS-1, SS-1H, CRS-1, CRS-2, CSS-1, CSS-1H.

305.20 APPLICATION OF BITUMINOUS MATERIALS

Bituminous material shall be uniformly applied with a pressure distributor at a rate no less than 0.03 gallons per square yard (residual asphalt). The contractor may cut the material back as recommended by the manufacturer for ease in application.

When required by the Engineer or his Designee, the tack coat shall be rolled with a self-propelled pneumatic roller.

305.30 WEATHER LIMITATIONS

Shall meet the requirements of Section 340, BITUMINOUS PAVEMENT.

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SECTION 310 PAVING FABRIC

310.00 DESCRIPTION

This work shall consist of placing a paving fabric as part of a pavement rehabilitation project in compliance with the plans and specifications, and as directed by the Engineer.

The Contractor shall furnish all materials, labor, tools, equipment, and any other appurtenances necessary to complete the work.

310.10 MATERIALS

- A. Fabric Properties. The fabric must consist of woven or nonwoven polypropylene and/or polyester material meeting the following requirements when tested in conformance with the respective test method:

PROPERTY	ASTM DESIGNATION TEST	VALUE	UNIT
Weight (full roll)	ASTM D 3776, Option A	5.0 to 8.0	oz/sq yd
Thickness	ASTM D 1117-64	60.0 min.	mils.
Grab Tensile Strength	ASTM D 1117-80	100.0 min.	pounds
Elongation at Break	ASTM D 1117-80	50.0 min.	percent
Asphalt Retention	ASTM D 1117-80 NONE	0.20	gal/sq yd

- B. Sampling and Testing.

1. Testing. Specimens will not be conditioned for testing. The number of samples listed below will be tested initially; if the average test results indicate the material meets specification requirements no additional testing will be done. If the test results indicate the material does not meet specifications, the Contractor will be required to provide additional testing as directed by the Project Engineer.

SQUARE YARDS	NO. OF SAMPLES
0 - 50,000	8
50,000 - 150,000	16
150,000 - 300,000	24
Over 300,000	32

2. Test Samples. Test samples will be cut at the project location from rolls selected at random and shall be no less than three feet (3') in length by the full width of the roll. Nothing in this section shall deprive the Project Engineer of taking additional samples.
- C. Tack Coat. The tack coat shall be composed of paving grade bituminous material of the type and grade specified by the manufacturer of the fabric and shall be approved by the Project Engineer prior to its application.

310.20 CONSTRUCTION REQUIREMENTS

- A. Weather Limitations. Shall meet requirements of Section 340, BITUMINOUS PAVEMENT.
- B. Surface Preparation. Prior to tack coat application, all cracks wider than 0.50 inches shall be sealed with a rubberized asphalt concrete crack sealant. All joints and cracks shall be cleaned out and sealed as directed by the Engineer.
- C. Fabric Handling Equipment. Mechanical laydown equipment shall be capable of laying the fabric smoothly without excessive wrinkles or folds.

310.30 APPLICATION AND PLACEMENT OF MATERIALS

- A. Tack Coat. The tack coat shall be applied in accordance with the fabric manufacturer's recommendations. The tack coat width shall be six inches (6") wider than the fabric width when two (2) or more parallel sections are laid.
- B. Paving Fabric.
1. The Contractor must have qualified workmen or manufacturer trained representatives to supervise placement of the paving fabric.
 2. The paving fabric shall be stretched, aligned, and placed entirely on the tack coat with a minimum of wrinkles and folds. If folds in excess of one-half inch (1/2") occur, the fabric shall be slit to remove the fold or wrinkle then overlapped in the direction of the paving. Hand and mechanical brooming shall be effected to maximize the fabric contact with the tacked roadway surface.
 3. The fabric shall be rolled when required to seat the fabric to prevent movement and assure

fabric saturation.

Care shall be taken to avoid tracking plant mix bituminous pavement material onto the fabric and to avoid distorting the fabric during rolling.

4. If necessary, a small quantity of plant mix bituminous pavement material may be spread over the top of the fabric immediately in advance of the paving operation to prevent the fabric from being picked up by construction equipment.
5. No vehicle shall be allowed on the fabric, except rolling equipment, paving equipment, and cross traffic or as directed by the Engineer.
6. Paving operations shall follow placement of the paving fabric within one (1) hour or within one-quarter (1/4) mile, whichever is less.
7. No paving fabric shall be laid unless it will be paved over the same day in which it is laid.

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SECTION 315 COLD MILLING OF BITUMINOUS SURFACES

315.00 SCOPE OF WORK

This work shall consist of milling and removing excess or defective asphalt material from road surfaces.

315.10 MILLING OPERATIONS

- A. Curb line cold milling shall consist of milling to a depth of $1.5" \pm 1/2"$ at the curb apron or edge of pavement tapering to meet the pavement surface seventy-two inches (72") from the curb apron.
- B. The same process will apply for shoulder milling operations.
- C. Intersection and surface milling will consist of regular milling of pavement surfaces to a depth of $(1.5" \pm 1/2")$.
- D. The milling machine must be equipped with grade control devices to monitor referenced grade lines.
- E. Any adjustment to the plan depth and/or the depth established by the Project Engineer shall be in one-half inch ($1/2"$) increments. Said increments may be plus or minus (\pm) and shall be effected whenever and wherever the Project Engineer deems the adjustment in the work is necessary.

The Project Engineer shall be the sole judge as to said adjustment. The aforementioned adjustments will be made to the established profile grades from the existing pavement surface or from an independent grade control with cross slope elevation control.

- F. Excessive grooving by cold milling will not be permitted. Excessive grooving for all purposes of these specifications will be defined as any variation in the milled surface in excess of one-quarter inch ($1/4"$) from the high point to the low point across the width of the cutting head of the milling machine. Measurement shall be made to the bottom of the groove from a straight edge datum plane. When excess grooving occurs, cold milling operations shall cease and the equipment will be corrected.

315.20 EQUIPMENT

The cold milling machine shall be an approved pavement profiler meeting the following minimum requirements:

- A. The equipment must be a power operated planing or grinding machine capable of removing in one (1) pass; a layer of bituminous pavement material to a depth of $1.5" \pm 1/2"$ with a cutting width capable of performing the milling without loss of grade control.

- B. The cutting area of the equipment shall be enclosed and must have an effective means of dust control.
- C. The cold miller must be equipped with a grade reference control device with a tolerance of plus or minus one-eighth inch ($\pm 1/8''$) by reference from the existing pavement surface.
- D. The equipment shall be capable of reclaiming at least ninety-five percent (95%) of the milled material. Ninety-five percent (95%) of the milled material must be picked up immediately after the final pass of the cold miller. The use of a vacuum or pick-up type sweeper may be required.

315.30 HAULING OF MILLED MATERIALS

The pavement material emanating from the cold milling operation shall be removed immediately and disposed of at an approved disposal site located by the Contractor. If directed by the Engineer, the material will be delivered and tailgated on City property within three (3) miles of the worksite.

SECTION 320

COLD MIXED ASPHALT MATERIAL

320.00 GENERAL

This specification covers the production of cold mixed asphalt concrete surface course material for use in minor and temporary maintenance operations.

320.10 AGGREGATE MATERIALS

1. GRADINGS - Aggregates gradations for emulsified dense graded cold mixed asphalt material shall conform to the following:

SIEVE SIZE	PERCENT PASSING BY WEIGHT
½"	100
3/8"	90-100
No. 4	60-80
No. 8	35-65
No. 50	6-25
No. 200	2-10

2. SAND EQUIVALENT - shall be a minimum of 45.
3. L.A. WEAR (@ 500 revolutions) - shall be a maximum of 40.
4. FRACTURED FACES - minimum of 65% of aggregate shall have a minimum of one fractured face.

320.30 ASPHALT MATERIALS

The asphalt emulsion used in the production of this material shall be of any of the following grades unless otherwise specified in the plans or specifications: MS, CMS, SS, CSS, AEF, AND HFMS emulsified asphalts. These materials shall conform to requirements outlined in ASTM D 977.

320.40 MIXING

Mixing shall be done in an asphalt production plant which shall contain at a minimum a mixer, asphalt storage tank, emulsion metering pump, controls for monitoring and controlling mix components, and a conveyor for feeding the aggregate. Pugmills may be used as well as continuous mixers.

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SECTION 325

ASPHALTIC CONCRETE SURFACE COURSE MATERIAL

325.00 GENERAL

This section outlines requirements for the production of asphalt concrete surface course materials. The materials produced in compliance with section shall be used in procedures detailed in sections 340, 345, 350, and 355 of these Standard Specifications as well as other asphalt applications as shown on the plans and supplemental specifications. Asphalt concrete shall be composed of a mixture of bituminous material, aggregate and filler if required.

325.10 AGGREGATES

1. COMPOSITION - Aggregate shall consist of quarried stone, crushed gravel, and filler conforming to the requirements specified herein.
2. CLASSIFICATION - The portion of these materials retained on the No. 4 screen shall be known as coarse aggregates; the portion passing the No. 4 screen shall be known as fine aggregates.
3. TESTING - Asphalt concrete aggregate will be tested with AASHTO or ASTM methods herein provided (Table 325.10) and such other test methods as may be required by the City of Las Cruces.

TABLE 325.10

ASPHALT CONCRETE AGGREGATE	
Sieve Analysis of Fine and Coarse Aggregate	AASHTO T-27 (ASTM C-136)
Mechanical Analysis of Extracted Aggregate	AASHTO T-30
Amount of Material Finer than No. 200 Sieve	AASHTO T-11 (ASTM C-117)
Liquid Limit	AASHTO T-89 (ASTM D4319)
Plastic Limit and Plasticity Index	AASHTO T-90 (ASTM D4318)
Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine	AASHTO T-96 (ASTM C-131);
Sampling Bituminous Paving Mixtures	AASHTO T-168 (ASTM D-979)
Sampling of Aggregates for Paving Mixtures	AASHTO T-2 (ASTM D-75)
Soundness of Aggregate by Use of Magnesium Sulfate	AASHTO T-104 (ASTM C-88)
Standard Specification for Coarse Aggregate for Bituminous Paving Mixtures *(See Fractured Faces notes below)	ASTM D-692

ASPHALT CONCRETE AGGREGATE	
Quantitative Extraction of Bitumen from Bituminous Paving Mixtures	AASHTO T-164 (ASTM D-2172)
Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens	AASHTO T-166 (ASTM D-2726)
Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus. Stability (lbs.) Flow	AASHTO T-245 (ASTM D-1559)
Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures	AASHTO T-209 (ASTM D-2041)
Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures	AASHTO T-269 (ASTM D-3203)

4. **FRACTURED FACES** - Not less than seventy-five percent (75%) by weight of the individual pieces of material retained on the No. 4 screen shall have two new fractured faces. Some sources of gravel contain angular particles which will perform similarly to a mechanically crushed particle. Where laboratory tests or service records indicate this to be true, such angular particles may be considered crushed. These sources shall be approved in writing by the Engineer.

To classify as a Fractured Face, the area of each face shall be equal to at least seventy-five percent (75%) of the smallest mid-sectional area of the piece. When two (2) fractures are contiguous, the angle between planes of fractures shall be at least thirty degrees (30°) to count as two (2) fractures.

5. **ELONGATION** - The aggregate shall not contain more than eight percent (8%) by weight of flat or elongated pieces. A flat particle is one having a ratio of length to thickness greater than five (5). An elongated particle is one having a ratio of length to width greater than five (5).
6. **SAND EQUIVALENT** - The combined aggregate shall have a minimum sand equivalent of 45.
7. **AGGREGATE GRADING** - The gradations listed in Table 325.20 shall be used for production of asphalt concrete surface course materials as indicated on the plans, specifications or as directed by the City of Las Cruces. The following gradations represent the extreme limits which shall determine suitability of aggregate for use from all sources of supply. The aggregate as finally selected for use in the work shall have a gradation within the limits designated in Table 325.20, close to the center of the band, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but shall be uniformly graded from coarse to fine.

TABLE 325.20

ASPHALT CONCRETE AGGREGATE GRADATIONS PERCENT PASSING			
Sieve Size	A	B	C
1"	100		
3/4"	80-100	100	
1/2"	65-85	75-100	100
3/8"	55-75	60-85	70-100
No. 4	35-55	45-65	45-70
No. 10	25-45	35-50	30-50
No. 40	10-25	15-30	15-30
No. 200	3-7	4-9	4-10

8. MINERAL FILLER - If mineral filler is used, it shall conform to ASTM D-242 or AASHTO M17.
9. FINE AGGREGATE - All material passing the No. 40 sieve shall be non-plastic.
10. COARSE AGGREGATE - Coarse aggregate shall consist of clean, sound durable material free from adherent coatings of clay, dirt, dust or other objectionable matter, or from an excess soft or disintegrated pieces, and shall have a percentage of wear not to exceed 40 after 500 revolutions, as determined by ASTM Standard C-131. The aggregate shall be sampled and tested for clay lumps and friable particles in compliance with ASTM D-75 and ASTM C-142 respectively. No more than 2% by weight of such contaminant will be permitted.

325.20 ADDITIVES

- A. Hydrated Lime. Hydrated lime when needed shall conform with the requirements of ASTM Designation C 207, Type N, and shall be furnished in the amounts shown on the plans or established by the Mix Design.
- B. Non-strip Additive. Commercial non-strip additive may be used when indicated in the Job-Mix Formula.
- C. Filler. Filler material shall be non-plastic and quantity shall be determined by the Job-Mix Formula.

325.30 PRODUCTION

- A. When producing asphalt concrete classification A or B, the material shall be separated into stockpiles of fine and coarse aggregates which shall be built up with a minimum of segregation. The stockpile of fine or coarse aggregate shall contain a minimum of thirty-five percent (35%) of the total aggregate. The coarse aggregate shall have not more than ten percent (10%) passing the No. 10 sieve. The fine aggregate shall have no more than five percent (5%) of the material retained on the separating screens. Controlled feeders from each stockpile shall be used to blend the materials. When the materials from the stockpiles are combined, the product of such combination shall meet the gradation requirements herein provided. Deficiency in gradation shall be made up by the addition of the required material from separate stockpiles.

325.40 BITUMINOUS MATERIALS

1. TYPE AND GRADE - Bituminous materials shall be of the type, grade, and amount shown on the plans, specifications and/or job-mix formula, and shall conform with the type, grade, and all other requirements of the applicable placement section(s) [340, 345, 350, or 355] of these Standard Specifications. The type and grade of asphalt cement shall conform to Table 325.30 or 325.40 as follows.

TABLE 325.30

SPECIFICATIONS FOR ASPHALT CEMENT PENETRATION GRADE						
Specification Designation	60-70	85-100	120-150	150-200	200-250	AASHTO TEST METHOD
Flash Point (Open Cup) Degrees F, not less than	450	450	450	425	350	T-48
Penetration at 77°F 100g., 5 sec.	60-70	85-100	120-150	150-200	200-250	T-49
Thin Film Oven Loss, 325°F, 5 hrs., % not more than	0.75	0.75	0.75	1.00	1.00	T-179
Tests of residue from Thin- Film Oven Test: Penetration, % of original, not less than	50%	50%	50%	50%	50%	T-49
Solubility in CCl ₄ , not less than	99.5	99.5	99.5	99.5	99.5	T-44**
Reaction to Spot Test	Neg.	Neg.	Neg.	Neg.	Neg.	T-102*

* Using 85% Standard Naphtha Solvent and 15% Xylene.

** Procedure No. 1 with CCl₄ substitutes for CS.

TABLE 325.40

SPECIFICATIONS FOR ASPHALT CEMENT VISCOSITY GRADE					
TEST	AC-2.5	AC-5	AC-10	AC-20	AC-40
Viscosity, 60°C (140°F) poises	250±50	50±100	1000±200	2000±400	4000±800
Viscosity, 135°C (275°F), CS minimum	100	150	225	275	375
	Min-Max	Min-Max	Min-Max	Min-Max	Min-Max
Penetration, 25°C (77°F) 100 g 5 sec	200-340	130-160	80-110	55-80	40-60
Flash Point COC, Degrees C (Degrees F) minimum	160(325)	177(350)	219(425)	232(450)	232(450)
Solubility in trichloroethylene, percent-minimum	99.0	99.0	99.0	99.0	99.0
Tests on residue from thin-film oven test: Loss on heating, percent-maximum (Option)	1.0	1.0	0.5	0.5	0.5
Penetration of Residue, percent of original	40	46	50	54	58
Viscosity, 60°C (140°F) poises maximum	1000	2000	4000	8000	16000
* Ductility 25°C (77°F) 5 cm per minute, cm minimum	100	100	75	50	25
** Spot test (when and as specified) with: Standard naphtha solvent	Negative for all grades				
Naphtha-Xylene-solvent, % Xylene	Negative for all grades				
Heptane-Xylene-solvent, % Xylene	Negative for all grades				

* If ductility is less than 100, material will be accepted if ductility at 15.6°C (60°F) is 100 minimum.

** The use of the spot test is optional. When it is specified, the Materials Lab shall indicate whether the standard naphtha solvent or the naphtha-xylene solvent will be used in determining compliance with the requirement and also, in the case of xylene solvent, the percentage of xylene to be used.

2. Sampling and Testing Bituminous Materials. Samples of bituminous materials shall be supplied by the contractor. Tests considered necessary by the Engineer to determine

Conformance with specification after the receipt of refinery certificates will be performed by an approved testing laboratory. Materials shall be approved by the Engineer prior to use in the work. Additional samples of bituminous materials shall be furnished during construction, as required by the Engineer. Unless otherwise directed by the Engineer, ASTM Standard D 140 shall be used for sampling bituminous materials.

Refinery certificates shall be furnished with each shipment of bituminous material and each shipment shall be identified by seal numbers assigned at the refinery.

325.50 JOB-MIX FORMULA

The job-mix formula, with the allowable tolerances, shall be within the master range specified for the specified type of asphalt concrete. The job-mix formula for each mixture shall be in effect until modified in writing by the Engineer. The job-mix formula for each mixture shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate. After the job-mix formula is established, all mixtures for the project shall conform thereto within the following ranges of tolerances:

Passing No. 4 and larger sieves	± 7 percent
Passing No. 8 to No. 100 sieves (incl.)	± 4 percent
Passing No. 200 sieve	± 2 percent
Bitumen (extraction method ASTM D 2172)*	± 0.5 percent
Mixing Temperature	± 25° F
Placing Temperature	± 15° F
Hydrated Lime (when required)	± 0.3 percent
Stability (Marshall 75 Blows)	1800 lbs. plus
Flow (Marshall)	16 or lower
Sand Equivalent	45 Min.
Percent Air Voids	3 - 6 (Collectors/Arterials) 2 - 4 (Residential streets)
Immersion - Compression (AASHTO T 165)	73+
* (Nuclear Content Determination - ASTM D4125, AASHTO T287)	

Should a change in source of materials be made, a new job-mix formula shall be established before the new material is used. When unsatisfactory results are obtained, or the supplier cannot remain within the job-mix formula band as determined by the job-mix formula, the City of Las Cruces may require the supplier to cease operation until such corrective action is taken to remain within the job-mix formula band. The supplier shall furnish printed tickets with each load showing the weight of aggregates and weight of asphaltic material. The supplier shall furnish a current certification showing that the plant scales have been checked for accuracy when requested by the Engineer. In the event a change is made to the job mix formula, a revised original mix design must be submitted to the Project Manager for acceptance.

325.60 ACCEPTANCE

Liquid limit and plasticity index of asphalt concrete aggregate will be determined from representative samples taken after the aggregate materials have been blended and prior to mixing with bituminous material. The test results from these samples will be the basis for acceptance of such aggregate. The Engineer may sample and test the asphalt concrete aggregate at any time during production or stockpiling. Acceptance of asphalt concrete aggregate gradation will be based on tests made from representative samples taken after the asphalt concrete has been placed on the roadbed and prior to compacting. The acceptance of the asphalt concrete surface course material will be as specified on the plans and specifications and/or as a minimum shall comply with section 120 of these Standard Specifications.

325.70 MIXING

The bituminous mixture shall be produced in an approved plant as hereinbefore specified.

A. Preparation of Mineral Aggregates. Aggregates shall be divided in the hot bins to at least three (3) sizes. No individual aggregate size shall constitute more than three-fourths ($3/4$) of the total aggregate proportioned to the drier. The aggregate furnished shall be stockpiled in separate piles on sites prepared and maintained in such a manner as to prevent the mixing of deleterious substances with the aggregate. The stockpiles shall be separated by means of adequate bulkheads to prevent the intermingling of the various aggregates, or shall be separated so that a clear space of not less than twelve feet (12') can be maintained between the outer limits of adjacent piles. The stockpiles shall be constructed in successive horizontal layers to avoid segregations. Aggregates shall be taken from the stockpiles for delivery to the cold bins in such a manner that a reasonably uniform gradation is delivered to the plant. Stockpiles which show evidence of severe segregation shall be manipulated by special methods and/or equipment as necessary to overcome the effect of such segregation.

B. Preparation of Bituminous Mixtures.

Asphalt Mixture. The aggregates, prepared as specified hereinbefore, and dry mineral filler shall be accurately weighed or measured and conveyed into the mixer in the proportionate amounts of each aggregate size required to meet the job-mix formula. The required amount of asphalt for each batch, or calibrated amount for continuous mixing, shall be introduced into the mixer. In batch mixing, after the aggregates and mineral filler have been introduced into the mixer and mixed for not less than fifteen (15) seconds, the bituminous material shall be added and mixing continued for a period of not less than twenty (20) seconds and as much longer as may be required to obtain a homogeneous mixture. When a continuous mixer is employed, the mixing time shall be not less than thirty-five (35) seconds and as much longer as may be required to obtain a homogeneous mixture. The additional mixing time, when required, shall be determined by the Plant Operator. In no case shall the aggregate be introduced into the mixture at a temperature more than forty-five (45) degrees F above the temperature of the asphalt. The temperature of the bituminous material at the time of mixing shall not exceed three hundred, twenty-five (325) degrees F. The temperature of the aggregate and mineral filler in the mixer shall not exceed three hundred fifty (350) degrees F when the asphalt is added. The temperatures of both the aggregates and asphalt at the time of mixing shall be as determined by the Engineer. When the mixture is prepared in a twin-pugmill mixer, the volume of the aggregates, mineral filler, and bituminous material shall not be so great as to extend

above the tips of the mixer blades when the blades are in a vertical position. All over-heated and carbonized mixtures, or mixtures which foam or show indication of moisture, will be rejected by the Engineer. When moisture is detected in the finished mixture, all aggregates in the bin shall be removed and placed in their respective stockpiles.

325.80 TRANSPORTATION OF BITUMINOUS MIXTURES

1. Transportation of bituminous mixtures from the paving plant to the site shall be in trucks having tight, clean, smooth beds which have been oiled with a minimum amount of approved thin oil to prevent adhesion of the mixture to the truck bodies. Each load shall be covered with canvas or other suitable material of ample size to protect it from the weather and to prevent the loss of heat. Deliveries shall be made so that spreading and rolling of all the mixture prepared for a day's run can be completed during daylight. The mixture shall be delivered to the area to be paved in such manner that the temperature at the time of dumping into the spreader shall be between two hundred seventy (270) and a maximum of +25 degrees above the mix design temperature. Mix delivered at any temperature less than two hundred seventy degrees F. will be rejected on site. Any loads wet excessively by rain will be rejected by the Engineer. Hauling over freshly laid material will not be permitted.
2. The contractor shall provide a small hole (approximately 3/8" diameter) near the center on the left (drivers) side of all haul truck beds. The holes will be provided for ease in measuring the temperature of the materials when delivered to project sites.

325.90 INSPECTION OF PLANT AND EQUIPMENT

The Engineer and his Inspector shall have access at all times to all parts of the paving plant for checking the adequacy of the equipment in use, inspecting the operation of the plant, verification of weights, proportions, and character of materials, as well as checking temperature control being maintained in the preparation of the asphalt materials.

SECTION 330

RUBBER MODIFIED ASPHALT CONCRETE SURFACE COURSE MATERIAL

330.00 SCOPE

This specification covers procedures for producing asphalt concrete paving materials using a reacted asphalt-rubber binder. This specification includes the material, equipment, and construction procedures for a one-inch gap-graded Asphalt Rubber Overlay.

330.10 ASPHALT-RUBBER BINDER

The asphalt-rubber binder shall be a uniform reacted mixture of compatible paving grade asphalt cement, granulated reclaimed vulcanized rubber, and if required by the mix design, liquid anti-stripping agent. The asphalt-rubber binder shall be Type II binder and shall meet the following physical parameters when reacted at three hundred fifty degrees F (350°F) plus or minus ten degrees F ($\pm 10^\circ\text{F}$) for sixty (60) minutes:

PARAMETER	REQUIREMENT
Viscosity, Haake, 350° F	1500 - 6000 cp.
Cone Penetration, 77° F (ASTM D1191)	20-60
Softening Point, °F (ASTM D 36)	130° F min.
Resilience, 77° F (ASTM D 3407)	20% min.
Penetration, 39.2°F, 200g, 60 sec. 1/10 mm (ASTM D5)	15 min.

330.20 ASPHALT CEMENT

The asphalt cement for the asphalt-rubber binder shall be AC-10 and shall comply with the requirements of ASTM D 3381. The grade selected shall be determined by laboratory testing performed by the asphalt-rubber supplier to insure appropriate compatibility and reaction characteristics.

330.30 GRANULATED RECLAIMED VULCANIZED RUBBER

The rubber used shall be produced by the ambient temperature grinding process of automobile and truck tires. The gradation of the rubber when tested in accordance with ASTM C 136 shall meet the following requirements:

SIEVE SIZES	PERCENT PASSING GAP GRADED
No. 8	100%
No. 10	95 - 100%
No. 16	40 - 60%
No. 30	0 - 20%
No. 50	0 - 10%
No. 200	0

The use of rubber of multiple types from multiple sources is acceptable provided that the overall blend of rubber meets the gradation requirements.

The granulated rubber shall have a specific gravity of 1.15 ± 0.05 and shall be free of loose fabric, wire, and other contaminants except that up to four percent (4%) (by weight of rubber) calcium carbonate or talc may be added to prevent rubber particles from sticking together. The rubber shall be sufficiently dry so as to be free flowing and not produce a foaming problem when blended with the hot asphalt cement.

The length of the individual rubber particles shall not exceed three-sixteenths inch (3/16") (5mm).

The granulated rubber shall be accepted by certification from the rubber supplier.

330.40 ANTI-STRIPPING AGENT

If required by the job-mix formula to produce appropriate water resistance, an anti-stripping agent that is heat stable and approved for use by the specifying agency shall be incorporated into the asphalt-rubber material at the percentage required by the job-mix formula. It shall be added to the asphalt cement prior to blending with the granulated rubber.

330.50 ASPHALT-RUBBER BINDER MIXTURE DESIGN

The mix design shall be performed by the asphalt-rubber supplier. The proportion of granulated rubber shall be between eighteen (18) and twenty-one percent (21%) by weight of the total mixture. The asphalt-rubber supplier shall supply to the Engineer a mix formulation at least ten (10) days before pavement construction is scheduled to begin. The mix formulation shall consist of the following information as well as those listed under Section 303.11.

Asphalt Cement

- Source of Asphalt Cement
- Grade of Asphalt Cement
- Percentage of Asphalt Cement by total weight of the Asphalt-Rubber mixture

Granulated Reclaimed Rubber

- Source of Granulated Rubber
- Grade of Granulated Rubber

- Percentage of Granulated Rubber by total weight of the Asphalt-Rubber mixture

Anti-Strip Agent

- Source of Anti-Strip
- Grade of Anti-Strip
- Percentage of Anti-Strip by weight of Asphalt.

Temperatures

- Mixing Temperature
- Laydown Temperature

330.60 ASPHALT-RUBBER MIXING AND PRODUCTION EQUIPMENT

All equipment utilized in production and proportioning of the asphalt-rubber binder shall be described as follows:

- A. An **asphalt heating tank** with a hot oil heat transfer system or retort heating system capable of heating asphalt cement to the necessary temperature for blending with the granulated rubber. This unit shall be capable of heating a minimum of two thousand five hundred (2,500) gallons of asphalt cement.
- B. An **asphalt-rubber mechanical blender** shall have a two (2) stage continuous mixing process capable of producing a homogenous mixture of asphalt cement and granulated rubber, at the mix design specified ratios, as directed by the Engineer. This unit shall be equipped with a granulated rubber feed system capable of supplying the asphalt cement feed system, as not to interrupt the continuity of the blending process.
The maximum capacity of the blending tank shall be 500 gallons to ensure thorough mixing. Both the primary and secondary blenders must be equipped with an agitation device within the blending vessel. A separate asphalt cement feed pump and finished product pump are required. This unit shall have both an asphalt cement totalizing meter in gallons and a flow rate meter in gallons per minute.
- C. An **asphalt rubber storage and reaction tank** equipped with a heating system to maintain a temperature of 300°F to 375°F for reacting, pumping, and for adding the binder to the aggregate. The maximum capacity of the storage and reaction tank shall be 8,000 gallons. The storage and reaction tank shall have an internal mixing device capable of maintaining a uniform mixture of asphalt cement and granulated crumb rubber.
- D. An **asphalt-rubber supply system** equipped with a pump and metering device capable of adding the binder by volume to the aggregate at the percentage required by the job-mix formula.
- E. An **armored thermometer** of adequate range in temperature reading shall be fixed in the asphalt rubber feed line at a suitable location near the mixing unit.

330.70 ASPHALT-RUBBER MIXING AND REACTION PROCEDURE

- A. Asphalt Cement Temperature. The temperature of the asphalt cement shall be between 375°F and 450°F at the addition of the granulated rubber.

- B. Blending and Reacting. The asphalt and granulated rubber shall be combined and mixed together in a blender unit, pumped into the agitated storage tank, and then reacted for a minimum of forty-five (45) minutes from the time the granulated rubber is added to the asphalt cement. Temperature of the asphalt-rubber mixture shall be maintained at not less than 350°F during the reaction period. The asphalt rubber may be allowed to cool between 300°F and 350°F after it has reacted for the specified period.
- C. Transfer. After the material has reacted for at least forty-five (45) minutes, the asphalt-rubber shall be metered into the mixing chamber of the asphalt concrete production plant at the percentage required by the job-mix formula.
- D. Delays. When a delay occurs in binder use after its full reaction, the asphalt-rubber shall be allowed to cool. The asphalt-rubber shall be reheated slowly just prior to use to a temperature between three hundred and three hundred seventy five degrees fahrenheit (300°F and 375°F), and shall also be thoroughly mixed before pumping and metering into the hot plant for combination with the aggregate. The viscosity of the asphalt-rubber shall be checked by the asphalt-rubber supplier. If the viscosity is out of the range specified in these Standard Specifications, the asphalt-rubber shall be adjusted by the addition of additional asphalt cement or granulated rubber to produce a material with the appropriate viscosity.

330.80 MINERAL AGGREGATE

The aggregate for the asphalt concrete mixture shall be composed of hard durable particles of crushed stone or crushed aggregate. The aggregate shall be free from organic or decomposed materials, clay balls or lumps, adhered dust, and deleterious coatings (The aggregate materials shall be non-plastic). Angular natural sand or manufactured sand may be used as the fine aggregate portion. Rounded natural sands are not permitted. Mineral filler, if used, shall meet requirements of ASTM D242 or AASHTO M17.

330.90 AGGREGATE REQUIREMENTS

- A. Fractured Faces. The aggregate retained on the No. 4 screen shall consist of at least seventy-five (75%) particles which have at least two (2) new fractured faces.
- B. Abrasion Loss. The aggregate shall have an abrasion loss which does not exceed forty percent (40%) with ASTM C131 or AASHTO T96.
- C. Sand Equivalent Value. The sand equivalent value of the aggregate shall be a minimum of forty-five (45) when tested in accordance with ASTM D2419 or AASHTO T176.

D. Gradation. The gradation of the aggregate shall meet the following limits:

SIEVE SIZE	PERCENT PASSING
	GAP GRADED *
1"	
3/4"	
1/2"	100
3/8"	85 - 100
No. 4	30 - 40
No. 8	15 - 25
No. 40	5 - 15
No. 200	3 - 7

* Add 1 1/2% Hydrated Lime by weight.

330.95 JOB-MIX FORMULA

A. The mix design for this portion of the project will be provided by the asphalt-rubber supplier. The asphalt-rubber supplier will sample the material and determine the required parameters. The design method used shall be approved by the Engineer. The mix design shall be submitted to the Engineer at least ten (10) days prior to construction.

Based on information contained in the mixture design, the Engineer shall approve a job-mix formula with the following tolerances allowed for single tests on aggregate gradation and asphalt-rubber binder content.

AGGREGATE GRADATION	SIEVE SIZE	PERCENT TOLERANCE
	1/2 inch and larger	± 8%
	3/8 inch	± 7%
	No. 4, No. 8	± 7%
	No. 30	± 5%
	No. 200	± 2%
	Asphalt-Rubber Binder Content	± 0.5% *

* By Extraction Method

The asphalt-rubber/aggregate mixing equipment shall be capable of producing a paving mixture meeting all of the requirements contained in this specification. Specifically, the plant shall provide proper aggregate gradation, asphalt-rubber binder content and mixing temperature as outlined in section 325 and as directed by the Engineer.

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SECTION 335

PLANT MIXED SEAL COAT

335.00 DESCRIPTION

This work shall consist of mixing, in a central plant, aggregate and bituminous materials, spreading and compacting the mixed material on prepared roadbed, in substantial compliance with the specifications and the dimensions shown on the plans. Reference shall also be made to the most current version of the New Mexico State Highway Department Standard Specifications for Road and Bridge Construction.

335.10 MATERIALS

A. Aggregate

1. The aggregate shall be crushed stone or gravel, composed of hard durable pebbles or fragments plus a filler of finely crushed gravel, stone or sand, if necessary, so as to provide a material that will meet the following grading requirements when tested by means of AASHTO Methods T 11 and T 30 unless otherwise shown on the plans.

SIEVE DESIGNATION	PERCENT OF WEIGHT PASSING SQUARE MESH SIEVE
1/2"	100%
3/8"	90-100 %
No. 4	25-55 %
No. 10	0-12 %
No. 40	0-8 %
No. 2	0-4 %

2. At least seventy-five percent (75%) of the material retained on the No. 4 sieve shall be particles having at least two (2) fractured faces.
3. The aggregate shall be free from vegetable matter, lumps or balls of clay, adherent films of clay, or other material that will prevent thorough coating with asphaltic material.
4. The aggregate shall have a percentage of wear of not more than forty (40) at five hundred (500) revolutions, as determined by AASHTO Method T 96.

B. Bituminous Material

The bituminous material shall be asphalt cement of the grade as specified by the Engineer.

335.20 CONSTRUCTION METHODS

- A. Preparation of Roadbed. Prior to placing plant mixed seal coat, all foreign matter shall be cleaned from the surface of the existing roadbed.
- B. Tack Coat. When required, a tack coat of bituminous material of the type, grade, and quantity shown on the plans shall be applied to the surface of the prepared roadbed prior to the placement of the plant mixed seal coat.
- C. All plant mixed seal coat shall be placed at a thickness not to exceed five eighths inch (5/8") or 75 lbs. per sq. yd. by means of an approved type of paving machine.

SECTION 340

BITUMINOUS PAVEMENT

340.00 GENERAL

This work shall consist of constructing one or more courses of bituminous pavement on a prepared base in substantial compliance with the specifications, lines, grades, thicknesses, and typical cross-sections shown on the plans.

340.10 MATERIALS

Asphalt concrete surface course material shall be composed of a mixture of bituminous material, aggregate and filler if required in compliance with Section 325 of these Standard Specifications. The following types of materials shall be used for application to various roadway types (Locations) unless otherwise specified on the plans or by the Engineer.

LOCATION	ASPHALT CEMENT TYPE	AGGREGATE GRADING
PAVING OF RESIDENTIAL STREETS	PENETRATION GRADE 85-100 OR VISCOSITY GRADE AC-10	TYPE A OR TYPE B
PAVING OF COLLECTOR STREETS	PENETRATION GRADE 60-70 OR VISCOSITY GRADE AC-20	TYPE A
PAVING OF ARTERIAL STREETS	PENETRATION GRADE 60-70 OR VISCOSITY GRADE AC-20	TYPE A

340.20 EQUIPMENT

Equipment, tools, and machines used in the performance of the work covered by this section of the specifications shall be subject to the approval of the Engineer and shall be maintained in a satisfactory working condition at all times. All equipment proposed to be used for work under this section shall be of sufficient size and in such mechanical condition to be capable of completing the work and producing a good quality pavement.

A. Bituminous Pavers

1. Bituminous Pavers must have the following capabilities:

- a. Self-propelled
- b. Distributing screws/augers to all points of the screed area
- c. Adjustable (for crowns and width), vibratory and heatable screed
- d. Automatic leveling/grade control devices

- e. Receiving hopper of sufficient capacity for uniform operation
 - f. Variable speed
 - g. Spread hot bituminous mixtures without tearing, shoving, or gouging.
2. Bituminous pavers shall be designed such that no part of the truck weight will be supported by the paver.

B. Rollers

1. Rollers must have the following capabilities:
 - a. Shall be of the steel wheel and/or pneumatic-tire type.
 - b. Capable of reversing without backlash.
 - c. Shall be operated at speeds slow enough to avoid displacement of the bituminous mixture.
 - d. Shall be static type (vibratory may be used if approved by the Engineer).
 - e. Shall have smooth surfaced drum(s) and/or properly inflated tires.
2. The use of equipment which results in excessive crushing of the aggregate will not be permitted.

C. Power Blowers and Power Brooms

1. Blowers and brooms shall be of the power type and shall be suitable for cleaning the surface to be paved.

340.30 WEATHER LIMITATIONS

Asphalt concrete shall not be placed on any wet surface; when the surface temperature is below 50 degrees F; when the chill factor is below 45 degrees F (chill factor is defined as the ambient temperature in degrees F minus the wind velocity in MPH); or when weather conditions otherwise prevent the proper handling or finishing of the bituminous mixtures. The wind velocity shall be the velocity in MPH determined by the average of the maximum and minimum wind velocity observed in any three (3) minute period immediately prior to or concurrent with ongoing PMBP placement operations taken at five feet (5') above the surface of the road.

340.40 PLACING

Prior to transporting the surface course mix to the jobsite, a sand equivalent sample will be taken from the hot plant pugmill. The sand equivalent shall be no less than 45. Prior to laying the surface course, the underlying course shall be cleaned of all foreign or objectionable matter with power blowers, power brooms, or hand brooms. The surface course shall be placed on a prepared base with an approved prime coat conforming to Sections 210 and 300 of these Standard Specifications, or as indicated on the plans and as directed by the Engineer. During the application of prime and tack coats, care shall be taken to prevent splattering on adjacent pavement, curb and gutter, and structures. Any material inadvertently splattered shall be promptly removed by suitable means.

The minimum thickness of the compacted surface course shall be two inches (2") unless otherwise specified on the plans or specifications. The contractor shall be responsible for monitoring the thickness of the pavement and ensure the material placed is evenly spread on the roadway to a depth that after rolling will be of the specified cross section and grade specified.

Material application shall cease if the wind velocity exceeds 25 MPH. The wind velocity shall be the velocity in miles per hour determined by the Projects Inspector by averaging the maximum and minimum wind velocity observed in any three (3) minute period prior to or concurrent to ongoing operations. The wind velocity shall be measured three feet above the roadway surface.

340.50 COMPACTION OF MIXTURE

Compaction shall be effected by the rubber-tired rollers and tandem rollers (steel wheel) specified hereinbefore. Rolling of the mixture shall begin as soon after placing as the mixture will bear the roller without undue displacement. Delays in rolling freshly spread mixture will not be tolerated. Alternate trips of the roller shall be of slightly different lengths. The initial longitudinal rolling shall be effected by the use of tandem rollers.

Rollers shall move at a slow, not to exceed 3 MPH (264 Ft/min.), uniform speed, with the drive roll or wheels nearest the paver. The speed of the paving machine shall be coordinated with the production of the plant to achieve a continuous operation. Sufficient hauling equipment shall be available to insure continuous operation. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The surface course shall be compacted to a minimum of 96% of the laboratory density. No leakage from any roller shall be allowed to come in contact with the pavement being constructed nor shall any roller be permitted to stand motionless on any portion of the work before it has been properly compacted. Steel roller wheels shall be treated with water and detergent or oil to prevent the adherence of the asphalt concrete, also water and detergent or oil may be used on pneumatic-tired rollers but the quantity used must not be such as to be detrimental to the surface being rolled.

Final rolling of the top or finish course shall be accomplished with a steel wheel roller, removing all surface imperfections, including indentures made by pneumatic-tired rollers. Rolling of the surface shall be continued until all roller marks are eliminated and a density of at least ninety-six percent (96%) of the density of a laboratory specimen of the same mixture is attained.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand operated mechanical tampers. Any mixture that becomes mixed with foreign material or in any way is defective shall be removed, replaced with fresh mixture, and compacted to the density of the surrounding pavement.

If the pavement is constructed under a City of Las Cruces Road Construction Contract, reductions in payment for failing densities shall be taken in compliance with Section 120 of these specifications. If the pavement is constructed in conjunction with any other development such as part of a private development (Sub-division), failing densities shall be remedied as directed by the Chief Engineer or his Designer.

340.60 JOINTS

- A. General. All joints shall present the same texture, density, and smoothness as other sections of the course. Care shall be exercised in connection with the construction of joints to insure that the surface of the pavement is true to grade and cross section. All joints shall be completely bonded. The joints between old and new pavements or between successive days' work shall be carefully made in such manner as to insure a continuous bond between old and new sections of the course. All contact surfaces of previously constructed pavements shall be painted with a thin uniform coat of hot bituminous material just before the fresh mixture is placed.

All joints shall be properly "set up" with the back of the rake at a proper height and level to receive the maximum compression under the rolling. Work of setting up the joints shall be done by competent workmen who are capable of making a correct, clean, and neat joint. All joints shall be constructed within the smoothness requirements stated herein. To avoid segregation, any excess aggregate remaining on or near the joint area, after it is set up, shall be removed from the pavement surface and must not be broadcast across the new pavement mat.

- B. Transverse. The roller shall pass over the unprotected end of the freshly laid mixture only when the laying of the course is to be discontinued or when delivery of mixture is interrupted to the extent that the unrolled material may become cold. In all cases, the edge of the previously laid course shall be cut back to expose an even vertical surface for the full thickness of the course.
- C. Longitudinal. When the edges of the longitudinal joints are irregular, honeycombed, or poorly compacted, all unsatisfactory sections of joint shall be cut back to expose an even, vertical surface for the full thickness of the course prior to constructing the adjacent pavement.

340.70 SMOOTHNESS

The surface of the pavement after compaction shall be true to the lines and grades shown on the plans. When tested with a 10' straight edge placed in any direction, the surface shall not vary more than 3/16 of an inch between any two contacts with the surface. Transverse and longitudinal joints shall also be checked for smoothness. Joints shall not vary from the edge of a straight edge placed perpendicular to the joint by more than 1/8 of an inch.

All humps or depressions exceeding the specified tolerances shall be corrected immediately as directed by the Engineer.

340.80 PROTECTION OF PAVEMENT

After final rolling, no vehicular traffic shall be permitted on the pavement until it has cooled and hardened.

340.90 CLEANING

The Contractor shall, as directed by the Engineer, remove at his/her own expense from the Owner's property and from all public and private property, all temporary structures, rubbish, debris, or any waste materials resulting from his/her operations. He/she shall leave the entire site in a neat condition.

SECTION 345

BITUMINOUS PAVEMENT OVERLAY

345.00 DESCRIPTION

This work shall consist of constructing a single course of bituminous pavement on a prepared asphalt surface in substantial compliance with these specifications, thicknesses, and typical cross-sections described herein.

345.10 MATERIALS

Asphalt concrete surface course material shall be composed of a mixture of bituminous material, aggregate and filler if required in compliance with Section 325 of these Standard Specifications. The following types of materials shall be used for application to various roadway types (Locations) unless otherwise specified on the plans or by the Engineer.

LOCATION	ASPHALT CEMENT TYPE	AGGREGATE GRADING
OVERLAY RESIDENTIAL STREETS	PENETRATION GRADE 85-100 OR VISCOSITY GRADE AC-10	TYPE A OR TYPE B
OVERLAY COLLECTOR STREETS	PENETRATION GRADE 60-70 OR VISCOSITY GRADE AC-20	TYPE A
OVERLAY ARTERIAL STREETS	PENETRATION GRADE 60-70 OR VISCOSITY GRADE AC-20	TYPE A

345.20 EQUIPMENT

Equipment, tools, and machines used in the performance of the work covered by this section of the specifications shall be subject to the approval of the Engineer and shall be maintained in a satisfactory working condition at all times. All equipment proposed to be used for work under this section shall be of sufficient size and in such mechanical condition to be capable of completing the work and producing a good quality pavement.

Equipment shall conform to the requirements of Section 340.20 of these Standard Specifications.

345.30 WEATHER LIMITATIONS

Weather limitations shall conform to Section 340.30 of these Standard Specifications.

345.40 PLACEMENT

- A. SWEEPING - Prior to laying the surface course, the underlying course shall be cleaned of all foreign or objectionable matter with power blowers, power brooms, or hand brooms.
- B. SURFACE PREPARATION - The surface of the existing roadway shall be crack sealed (after cold milling is complete, if applicable) with an approved material such as asphalt emulsion and sand. All cracks equal to or greater than ½" in width shall be sealed. The Engineer must approve of the material and procedure before it is used. All severely raveled or uneven areas shall be patched prior to the placement of the overlay. After the entire area has been cleaned, crack sealed, and patched, the roadway shall receive a tack coat. All debris shall be removed from the gutters before the tack materials are placed.
- C. TACK COAT - An asphalt emulsion tack coat shall be applied to the surface prior to overlaying in conformance with Section 305 of these Standard Specifications. No greater area shall be treated in any one day than will be covered by an overlay that same day. Traffic will not be permitted on the tack coat. When required, the roadway surface of all cold pavement joints, curbs, gutters, manholes, and the like shall be painted with a tack coat immediately before the adjoining asphalt concrete is placed. Surfaces to receive the tack coat shall be cleaned to the satisfaction of the Engineer before the tack coat is applied.
- D. THICKNESS - The thickness of the overlay shall be as described on the plans, supplemental specifications, or contract documents. Unless otherwise specified, a minimum thickness of 1½" will be required. The thickness must be monitored in the field by the contractor. The asphalt concrete shall be evenly spread upon the roadway to a depth that after rolling will be of the specified cross section and grade specified. All roadways will be paved in increments of width not to exceed 12 feet unless authorized in writing to do so by the Engineer.
- E. ACCEPTANCE - The City of Las Cruces may have a representative at the project site when asphalt material is delivered. The City's representative will be responsible for collecting the material haul tickets, recording the time of placement, location of placement, material temperature, and quantity of material delivered only. In the event the City does not have a representative present, the contractor shall provide the above listed information for reference. The acceptance of the material shall be based on results from laboratory tests done on the materials in compliance with the specifications and asphalt mix design criteria.

345.50 COMPACTION OF MIXTURE

Compaction shall be effected by the rubber-tired rollers and tandem rollers (steel wheel) specified hereinbefore. Rolling of the mixture shall begin as soon after placing as the mixture will bear the roller without undue displacement. Delays in rolling freshly spread mixture will not be tolerated. Alternate trips of the roller shall be of slightly different lengths. The initial longitudinal rolling shall be effected by the use of tandem rollers.

The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. No leakage from any roller shall be allowed to come in contact with the

pavement being constructed nor shall any roller be permitted to stand motionless on any portion of the work before it has been properly compacted. Steel roller wheels shall be treated with water and detergent or oil to prevent the adherence of the asphalt concrete, also water and detergent or oil may be used on pneumatic-tired rollers but the quantity used must not be such as to be detrimental to the surface being rolled.

Final rolling of the top or finish course shall be accomplished with a steel wheel roller, removing all surface imperfections, including indentures made by pneumatic-tired rollers.

Rollers shall move at a slow, not to exceed 3 MPH (264 Ft/min.), uniform speed, with the drive roll or wheels nearest the paver.

Rolling of both the surface shall be continued until all roller marks are eliminated and a density of at least ninety-six percent (96%) of the density of a laboratory specimen of the same mixture.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand operated mechanical tampers. Any mixture that becomes mixed with foreign material or in any way is defective shall be removed, replaced with fresh mixture, and compacted to the density of the surrounding pavement.

The asphalt material shall be tested for compaction in the field. Base densities will be taken by an independent lab and finished densities will be taken at the same locations. There will be a minimum of three density tests taken to represent each street or 500 tons whichever is less. In the event the average density on any given street (as measured by the City's designated testing laboratory) is less than the 96% minimum, there will be two options to resolve the payment of the work.

One option will be to have a reduction in the unit price(s) for the work done as outlined in Section 120 of these Standard Specifications. Option two will be for the contractor to employ a materials testing laboratory (at his own expense) to core the finished roadway(s) in question at the same frequency (equal number of cores) as the City's nuclear tests. The contractor's laboratory will average the density determined from the cores to obtain a representative density for the entire roadway in question. If the resultant average core density meets or exceeds the 96% density requirement, the work will be paid for at the full contract unit price. If the resultant average core density does not meet the 96% requirement, the city will make the appropriate reduction in the unit price(s) according to the City's nuclear density determinations.

A price adjustment will be made according to the roadway density after all provisions listed above have been exhausted or selected by the contractor or the Engineer. In the event a reduction is made due to failed densities, a reduction will be made to bid items for the placement and compaction of the overlay surface course.

345.60 JOINTS

Construction of all joints shall conform to Section 340.60 of these Standard Specifications.

345.70 SMOOTHNESS

The smoothness of the overlay shall conform to the requirements outlined in Section 340.70 of these Standard Specifications.

345.80 PROTECTION OF PAVEMENT

After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it has cooled and hardened.

345.90 SPECIAL REQUIREMENTS - RUBBER MODIFIED OVERLAYS

When this section is specified for the construction of an asphalt rubber modified overlay, the use of rubber tire roller shall not be permitted. A minimum of two steel rollers shall be utilized for the compaction of the modified overlay.

345.95 CLEANING

The Contractor shall, as directed by the Engineer, remove at his/her own expense from the Owner's property and from all public and private property, all temporary structures, rubbish, debris, or any waste materials resulting from his/her operations. He/she shall leave the entire site in a neat condition as required by the Engineer.

SECTION 350

HEATER SCARIFICATION REPAVING PROCESS

350.00 DESCRIPTION

This work shall consist of heating, scarifying, rejuvenating, remixing, releveling, and laying a one course hot asphaltic concrete pavement in one operation.

350.10 SURFACE PREPARATION FOR MACHINE REPAVING PROCESSES

The Contractor shall supply and make available at all times all the necessary equipment required to clean and sweep the asphalt surfaces to be treated. Areas to be swept and cleaned are to be determined by the Engineer. A self-propelled power sweeper shall be used for sweeping. The Contractor shall also provide for adequate cleaning of cracks and gutter areas by compressed air or by other approved means suitable to the Engineer prior to the repaving operation.

350.20 MATERIAL

The asphalt concrete surface course material to be supplied may be specified under a separate contract between the City of Las Cruces and an asphalt production company. Unless otherwise specified, the material to be placed shall conform to Section 325, type B grading with penetration grade 85-100 or viscosity grade AC-10 asphalt cement. The approved mix design will specify a minimum temperature requirement for acceptance by the repaving crew.

The City will require an asphalt rejuvenating agent to be used as a part of the repaving and remixing process. The asphalt rejuvenating agent will be supplied and stored by the City of Las Cruces. The application rate for the rejuvenating agent will be 0.07 gallons per square yard unless otherwise specified by the Engineer.

350.30 EQUIPMENT

- A. REPAVING EQUIPMENT. The equipment that heats, scarifies, rejuvenates, mixes, and levels must also lay the new hot asphaltic concrete pavement. The new asphaltic concrete pavement must be laid within ten (10) seconds after the scarification begins to insure a hot monolithic bond with the old pavement. The repaving equipment must also be capable of performing the following:
1. Radiant Heating. Heat shall be uniformly applied to the asphalt pavement surface under controlled atmospheric conditions which will eliminate the presence of free oxygen under the heating chamber without burning the asphalt. All flames shall be shielded so that blasting or scrubbing of the existing asphalt is eliminated. The surface of the existing pavement shall be heated with continuously moving radiant heaters to allow the pavement to be scarified to a three-quarter inch (3/4") average depth in a single pass, hold the surface temperature of the old pavement below three hundred seventy-five degrees F (375° F), and produce reclaimed mix at a temperature not less than two hundred twenty degrees F (220° F). Heating methods shall meet all local, state, and federal pollution control regulations. The heating operation shall extend at least four inches (4") beyond

the width of scarification on both sides.

2. Scarification. The heated pavement shall be immediately scarified by carbide-tipped teeth set on less than one inch (1") centers mounted in multiple racks controlled from the operator's platform. Depth of scarification shall be three-quarters inch (3/4") average depth - scarification shall cut through the pavement at a level that comes within one-quarter inch (1/4") of being in alignment with grade and slope of the finished pavement. Special diagonal blade cutters must be used on the outside racks to cut back a one-half inch (1/2") deep by four inch (4") wide cut at curb apron or edge of adjoining pavement. The repaver must have enough power to push the scarifiers through the high spots and create a leveled surface conforming to the desired finished profile of the pavement. The scarifiers must be capable of adjusting the cut depth to go over manholes and other appurtenances.
3. Leveling. The repaver must be capable of using the recycled mix to create a leveling course of recycled paving material. A leveling blade shall lay the one-inch (1") minimum layer of the recycled mix at a level that comes within one-quarter inch (1/4") of being in alignment with grade and slope of finished pavement. The leveling blade must be equipped with an auger to move material in a transverse direction to center windrow. The repaver must also be capable of thoroughly applying and mixing into the existing asphalt materials sufficient heated liquid asphalt emulsion to restore flexibility, ductility, and cohesion. The Engineer shall determine if an asphalt emulsion rejuvenator is needed and the application rate of same. The City will supply the rejuvenating agent.
4. Screeding. Within a lapsed time of not more than ten (10) seconds and while the temperature of the recycled mix laid by the leveling blade is above two hundred degrees F (200° F), a new top layer of dense road asphalt shall be laid by a four-section vibratory screed. The screed shall be electronically controlled in both grade and slope sensed by a minimum twenty-four foot (24') long rolling straight edge running in adjacent lane. Basic minimum thickness of combined recycled and new mat at eighty-five percent (85%) compaction density behind the screed shall be one and one-half (1 1/2) and two inches (2").

B. Rollers

1. Rollers must have the following capabilities:
 - a. Shall be of the steel wheel and/or pneumatic-tire type.
 - b. Capable of reversing without backlash.
 - c. Shall be operated at speeds slow enough to avoid displacement of the bituminous mixture.
 - d. Shall be static type (vibratory may be used if approved by Engineer).
 - e. Shall have smooth surfaced drum(s) and/or properly inflated tires.
2. The use of equipment which results in excessive crushing of the aggregate will not be permitted.

C. Power Blowers and Power Brooms

1. Blowers and brooms shall be of the power type and shall be suitable for cleaning the surface to be paved.

350.40 WEATHER LIMITATIONS

Weather limitations shall conform to Section 340.30 of these Standard Specifications.

350.50 PLACING ASPHALT CONCRETE MIXTURE

At the time of delivery to the site of the work, the temperature of mixture shall be not lower than that required to obtain the density specified.

The Engineer shall require a temperature which laboratory tests show will be suitable for its workability. Materials shall be delivered to site of the work without segregation of the ingredients and within the temperature range specified by the Engineer.

Placing once commenced must be continued without interruption. No greater amount of the mixture shall be delivered in any one day than can be properly distributed and rolled during that day. In narrow, deep, or irregular sections, intersections, turnouts or driveways, where it is impractical to spread and finish the base and level the surface mixtures by machine methods, the contractor may use spreading equipment or acceptable hand methods approved by the Engineer.

350.60 COMPACTION OF MIXTURE

Compaction shall be effected by the rubber-tired rollers and tandem rollers (steel wheel) specified hereinbefore. Rolling of the mixture shall begin as soon after placing as the mixture will bear the roller without undue displacement. Delays in rolling freshly spread mixture will not be tolerated. Alternate trips of the roller shall be of slightly different lengths. The initial longitudinal rolling shall be effected by the use of tandem rollers.

Rolling shall be commenced with a steel wheel roller along the lower edge of the area to be rolled and be continued until the edge is thoroughly compacted, after which the roller shall be gradually advanced to the crown point, both sides being rolled in a like manner. Rolling shall be continued with steel and pneumatic wheel rollers until the layer has become thoroughly compacted throughout and is true to grade and cross section.

No leakage from any roller shall be allowed to come in contact with the pavement being constructed nor shall any roller be permitted to stand motionless on any portion of the work before it has been properly compacted. Steel roller wheels shall be treated with water and detergent or oil to prevent the adherence of the asphalt concrete, also water and detergent or oil may be used on pneumatic-tired rollers but the quantity used must not be such as to be detrimental to the surface being rolled.

Final rolling of the top or finish course shall be accomplished with a steel wheel roller, removing all surface imperfections, including indentures made by pneumatic-tired rollers. Rolling of both the surface shall be continued until all roller marks are eliminated and a density of at least ninety-six percent (96%) of the density of a laboratory specimen of the same mixture is attained.

Rollers shall move at a slow, not to exceed 3 MPH (264 Ft/min.), uniform speed, with the drive roll or wheels nearest the paver.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand operated mechanical tampers. Any mixture that becomes mixed with foreign material or in any way is defective shall be removed, replaced with fresh mixture, and compacted to the density of the surrounding pavement.

The asphalt material shall be tested for compaction in the field. Base densities will be taken by an independent lab and finished densities will be taken at the same locations. There will be a minimum of three density tests taken to represent each street or 500 tons whichever is less. In the event the average density on any given street (as measured by the City's designated testing laboratory) is less than the 96% minimum, there will be two options to resolve the payment of the work.

One option will be to have a reduction in the unit price(s) for the work done as outlined in Section 120 of these Standard Specifications. Option two will be for the contractor to employ a materials testing laboratory (at his own expense) to core the finished roadway(s) in question at the same frequency (equal number of cores) as the City's nuclear tests. The contractor's laboratory will average the density determined from the cores to obtain a representative density for the entire roadway in question. If the resultant average core density meets or exceeds the 96% density requirement, the work will be paid for at the full contract unit price. If the resultant average core density does not meet the 96% requirement, the city will make the appropriate reduction in the unit price(s) according to the City's nuclear density determinations.

A price adjustment will be made according to the roadway density after all provisions listed above have been exhausted or selected by the contractor or the Engineer.

350.70 JOINTS

Construction of all joints shall conform to Section 340.60 of these Standard Specifications.

350.80 SMOOTHNESS

The smoothness of the repaved surface shall conform to the requirements outlined in Section 340.70 of these Standard Specifications.

350.90 PROTECTION OF PAVEMENT

After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it has cooled and hardened.

350.95 CLEANING

The Contractor shall, as directed by the Engineer, remove at his/her own expense from the Owner's property and from all public and private property, all temporary structures, rubbish, debris, or any waste materials resulting from his/her operations. He/she shall leave the entire site in a neat condition as required by the Engineer.

SECTION 355

PATCHING ASPHALT PAVEMENTS

355.00 GENERAL

Patching of asphalt pavements shall consist of preparation of the patch area, placing, finishing and compacting with approved construction materials in substantial compliance with this specification. This specification is intended as a minimum guideline for construction of patches to City Streets and shall be followed unless otherwise specified by the Engineer.

355.10 MATERIALS

- A. Base Course material shall conform to Section 210, GRADED GRAVEL BASE COURSE.
- B. Flowable fill material shall conform to Section 515, FLOWABLE FILL. This material may be used in narrow trenches for ease in back filling to a point no closer than two inches from the pavement surface.
- C. Temporary Asphalt Patch material shall conform to Section 320, COLD MIXED ASPHALT unless it meets the criterion described in Section 355.20 below.
- D. Prime Coat material shall conform to Section 300, PRIME COAT.
- E. Permanent Asphalt Patch material shall conform to Section 325, ASPHALT CONCRETE MATERIAL. The Asphalt cement for all permanent patch material shall be viscosity grade AC-10 or penetration grade 85-100 unless specified otherwise on the plan. The grading of the material shall be Type C if the patch is less than 100 ft² in total area OR, less than 6" in width OR, on a residential street. The grading of the material for all other applications shall be Type A or B and/or equivalent to that of the surface being patched or as determined by the Engineer.

355.20 TIMELINESS OF PATCHING

If a patch is on any street other than a low volume residential street OR if a temporary patch is expected to be left for a period of time exceeding three days OR if a cut pavement is not safe for pedestrians and traffic to be left as a base or soil patch, the temporary patch material shall conform to Section 320, COLD MIXED ASPHALT.

If the patch is on a residential low volume street and will be permanently patched within a reasonable period of time as determined by the Engineer, then the patch material shall be an approved backfill material as directed by the Engineer.

355.30 EQUIPMENT

Equipment, tools, and machines used in the performance of the work covered by this section of the specifications shall be subject to the approval of the Engineer and shall be maintained in a satisfactory

working condition at all times. All equipment proposed to be used for work under this section shall be of sufficient size and in such mechanical condition to be capable of completing the work and producing a good quality patch.

355.40 WEATHER LIMITATIONS

- A. Permanent Asphalt Patches shall be placed only when weather permits as described by Section 340.30.
- B. If weather does not meet the requirements above, then a Temporary Patch shall be constructed until such time that weather permits the construction of a permanent patch.

355.50 PATCH PREPARATION

- A. Cuts - All patched areas shall be cut square or rectangular with straight edges in the horizontal and vertical directions. One pair of cut faces shall be at right angles to the direction of traffic.
- B. Base Preparation - Prior to placing the Permanent Patch, the underlying base course shall be cleaned of all foreign or objectionable matter. The base course shall be compacted to a minimum of 95% of the modified proctor as indicated on the plans or as directed by the Engineer. The depth of the compacted base course shall be a minimum of 6 inches or as directed by the Engineer.

If the patch is being placed to correct a pot hole and the depth of the hole has not extended into the base, the hole may be cut as described under paragraph A above, cleaned, dried, primed, and patched as indicated below. The Engineer may require the patch to be sealed with an approved emulsion if deemed necessary.

- C. Prime Coat - The Prime coat shall be applied at a rate to provide total coverage of all adjoining surfaces including the sides of the patch. If an emulsion is used for the prime material, ample time must be given to allow the prime to "break" before the patching material is placed.

355.60 PLACEMENT OF PERMANENT PATCHING MATERIALS

- A. The materials shall be placed around the perimeter of the patch area and raked toward the center of the patch to reduce segregation and concentration of aggregates at the joints. The materials shall also be dumped or placed and not thrown or broadcast to reduce segregation.
- B. The thickness of the compacted patch shall match the depth of the adjacent pavement surfaces and shall be a minimum of two inches (2") deep OR, as specified on approved plans and/or specifications OR, as directed by the Engineer.

355.70 COMPACTION

- A. Compaction shall begin by rolling a six inch wide section around the perimeter of the patch. After the perimeter rolling is complete, the entire patch area shall be rolled to a minimum of 96% of Modified Proctor.

B. Compaction shall be effected in compliance with Section 340.50 of these Standard Specifications.

355.80 JOINTS

All joints shall conform with Section 340.60 of these Standard Specifications.

355.90 SMOOTHNESS

All patches shall have the same smoothness requirements as outlined in Section 340.90 of these Standard Specifications.

355.95 CLEANING

The Contractor shall, as directed by the Engineer, remove at his/her own expense from the Owner's property and from all public and private property, all temporary structures, rubbish, debris, or any waste materials resulting from his/her operations. He/she shall leave the entire site in a neat condition as required by the Engineer.

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SECTION 400

ACRYLIC EMULSION FOG SEAL

400.00 SCOPE:

The work to be performed shall consist of furnishing required labor, material, equipment, parts and supplies necessary for the application of an Asphalt emulsion protective coating to prepared asphalt surfaces.

400.10 MATERIALS

- A. Asphalt Emulsion - The asphalt emulsion shall meet the requirements of Table 400-1, MATERIAL. The emulsion will be diluted with water in accordance with paragraph B below.
- B. Dilution - The dilution rate will be two (2) parts asphalt emulsion concentrate to one (1) part potable water. It is suggested that the dilution be formulated at the manufacturer's plant using warm soft water and proper blending techniques.
- C. Water - Water shall be potable and free from any deleterious substances that may affect the stability of the emulsion.
- D. Submittals - The contractor shall furnish a certificate of compliance from the manufacturer stating that the base emulsion being supplied meets the requirements of Table 400-1.

400.20 PREPARATION OF PAVEMENT

- A. Pavement surface - The pavement surface which is to receive the sealant must be sound, surface cured, and clean in order for the Acrylic modified asphalt emulsion to perform properly.
- B. Cleaning surface - The asphalt pavement surface shall be swept and cleaned by the contractor prior to the application of the emulsion. To be clean, the surface shall be free from sand, grease, dirt, and other foreign matter. Cleaning shall include the removal of grass from all joints and/or cracks in the surface if they exist. The pavement will not be sealed until it has been cleaned entirely. Cleaning shall be accomplished by means of power blowers, stiff bristle brooms, vacuum unit, or by pressure flushing.
- C. Deleterious matter - Any accumulation of grease or oil shall be removed by scraping, burning, or scrubbing with detergent (if detergent is used, it must be thoroughly rinsed from the surface). If oil is still soaked into pavement but the pavement is sound as determined by the Engineer, such areas shall be coated with an acrylic oil spot primer to promote better adhesion and to prevent bleeding.

400.30 EQUIPMENT

Equipment and tools necessary for unloading, transporting, and applying material and for performing and maintaining all parts of the work, satisfactory as to design, capacity, and mechanical condition for the purpose intended.

The distributor for spreading the emulsion shall be self-propelled and shall have pneumatic tires. The distributor shall be designed and equipped to distribute the emulsion uniformly on variable widths of surface at readily determined and controlled rates. The distributor must be capable of applying sealing material with an allowable variation from any specified rate not to exceed five percent (5%).

In the event the rate of application varies beyond the tolerance specified above, under-applications shall be corrected and any excess bituminous materials used in over-applications will be at the expense of the Contractor.

Distributor equipment shall include a curb shield, accurate volume measuring devices and a calibrated tank, and a measuring stick calibrated in fifty (50) gallon increments maximum. The distributor equipment shall include a hand hose attachment suitable for application of the emulsion manually to cover areas or patches inaccessible to the distributor. The distributor shall be equipped to circulate and agitate the emulsion within the tank.

400.40 APPLICATION OF MATERIAL

- A. Material temperature - The application temperature of the emulsion shall be between 120°F and 160°F. The contractor must use a delivery system that is equipped with heating and circulation capability to ensure the proper mixing and even distribution of the material.
- B. Weather Conditions - The emulsion shall be applied when the ambient air temperature is 50°F and rising and there is no threat of rain for an eight hour period. The material may be applied when the surface is dry or damp but not wet. The surface temperature must be at least 50°F and rising before the emulsion can be applied. Material application shall cease if the wind velocity exceeds 12 MPH. The wind velocity shall be the velocity in miles per hour determined by the Projects Inspector by averaging the maximum and minimum wind velocity observed in any three (3) minute period prior to or concurrent to ongoing fog sealing operations. The wind velocity shall be measured three feet above the roadway surface.
- C. Application rate - Apply sealer in one uniform coat with a mechanical distributor which has controlled rate capabilities and a spray wand. The application rate will be between 0.08 to 0.12 gallons per square yard of diluted material. The project Engineer or his designee will determine the actual application rate for each street.
- D. Protection of property - Any area that is not readily accessible for sealing by the distributor will be sealed with the use of squeegees, brooms, roller or spray wand. Any material sprayed or splattered on adjacent structures not intended to receive the seal coat shall be cleaned by the contractor at the time the over application occurs. Care shall be taken to prevent the spraying of the sealing material on that portion of pavement being used by traffic or areas not to be sealed. In the event that the sealant is splattered or picked up by traffic, it will be the contractors responsibility to remove and clean that material from the vehicles.
- E. Drying time - The typical drying time for this material will be 2 hours. The contractor must not allow traffic to travel on the surface until it is entirely dry and no longer tacky. Weather conditions will affect the drying time.

- F. Time of application - Acrylic sealant will be applied only between the hours of 8:30 a.m. and 2:30 p.m. All streets must be capable of being opened to traffic by 4:00 p.m..

400.50 TRAFFIC CONTROL

Traffic control responsibility - The contractor will be responsible for providing all of the traffic control for this project. Traffic control must conform to the Manual of Uniform Traffic Control Devices or the traffic control plan provided for in this contract document, whichever is more stringent. The Contractor may be allowed to completely close the street to be sealed if traffic control is adequate and no two adjacent streets are closed at the same time.

400.60 NOTIFICATION OF PUBLIC

The contractor shall provide each residence and business with a notice of when their street is to be sealed at least 24 hours in advance of work being done. This will provide adequate lead time for residents to move vehicles from the streets. The notice to be distributed shall be provided by the City of Las Cruces. Towing of any vehicle(s) will be done through the City of Las Cruces. Notices must not be placed in mail boxes.

400.70 POST APPLICATION

After application of the sealer, depressions in the pavement that collect residual sealer and puddles should be spread to avoid a tacky slow curing surface. Any material spread, tracked, spilled, or distributed on areas not intended to be sealed will be cleaned and/or removed by the contractor before proceeding with sealing operations at other locations. These areas include but are not limited to gutters, curbs, sidewalks, driveways and ramps. Removal of sealant from concrete surfaces shall be done by the use of a steel bristled brush or other suitable method approved by the Engineer. The use of solvents will not be permitted.

If any areas are tracked or do not get properly sealed, the contractor will be required to go back to those areas and touch up the unsealed areas at his own expense.

TABLE 400-1 MATERIAL

TEST ON EMULSION

TEST	METHOD	MIN	MAX
Viscosity, 77°F, sfs	AASHTO T-72	15	40
Sieve, %	AASHTO T-59	-	0.1
Acrylic solids, %	CAL 401, 4	12	-
Residue, %	AASHTO T-59	53	

TEST ON RESIDUE

Recovered base testing: Recovery of the modified base asphalt shall be accomplished by the use of AASHTO T-59 sections 13-15. After completing the recovery process, a minimum of 95% of the residue in each container must be recoverable in a homogeneous state for physical testing. Any clumps must be redispersible upon stirring.

TEST	METHOD	MIN	MAX
Elongation, max str., 77°F, (psi)	* (see 1 below)	25	-
Elongation @ break, (%)	* (see 1 below)	800	-
Exposure, Q.U.V.	* (see 2 and 3 below)	450	-
Softening point, (°F)	AASHTO T-53	130	-
Penetration @ 77°F, (dmm) (100g for 5 sec.)	AASHTO T-49	20	60
Ductility @ 77°F, (cm) (5cm/min)	AASHTO T-51	20	-

1. Dogbone 0.125 inch, aged 72°F, 50% R.H., one week before testing. Instron: one inch gap, 8 inches per minute.
2. Concentrate diluted with water (2:1), spread rate 80 square feet per gallon (25 mil dry film) on aluminum "Q-panels". Film cured for 48 hours at 72°F and 50% humidity.
3. Q.U.V. from Q panel company. Bulb type: QFS-40. Q.U.V. setting as follows: Set to conditions of 2.5 hours ultraviolet light at 175°F and 1/2 hour condensation at 82°F. Samples are inspected for cracking, crazing, charring and flow.
4. The uncured Acrylic Polymer Latex Elastomer shall be composed of 100% acrylic monomers formulated without plasticizer.

SECTION 405

HIGH FLOAT EMULSION FOG SEALING

405.00 SCOPE:

The work to be performed under this contract shall consist of furnishing required labor, material, equipment, parts and supplies necessary for the application of an Asphalt Emulsion Fog Seal on asphalt pavement surfaces.

405.10 MATERIALS

- A. Asphalt Emulsion - The asphalt emulsion shall be HFE-100P or equivalent and must meet the requirements of TABLE 405-1 below. The emulsion will be diluted with water in accordance with paragraph B below.
- B. Dilution - The dilution rate will be one part asphalt emulsion concentrate to one part potable water. It is suggested that the dilution be formulated at the manufacturer's plant using warm soft water and proper blending techniques.
- C. Water - Water shall be potable and free from any deleterious substances that may affect the stability of the emulsion.
- D. Submittals - The Contractor shall furnish a certificate of compliance from the manufacturer stating that the base emulsion being supplied meets the requirements of TABLE 405-1.
- E. Sand Blotter - Sand blotter material shall be low to non plastic. The sand blotter shall conform to Section 240 of these Standard Specifications.

TABLE 405-1 MATERIAL

TEST	VALUE
Viscosity, saybolt furol, at 122°F, sec.	50+
Sieve test, % retained on the 200 sieve	0.10-
24 hour Storage Stability, %	1.0 -
Coating test, 3 Min.	Stone coated thoroughly
Demulsibility, 35 ml, 0.02n, CaCl (2)	40+
Distillation test: Residue from dist. test to 400°F, %	65+
Oil Distillate, by Volume, %	2.0-
Characteristics from residue from dist. test to 400°F, Penetration at 77°F., 100g for 5 sec., 50g for 5 sec.	90-150

TEST	VALUE
Ductility 77°F, cm	125 min.
Float test at 140°F, sec.	1200+
Tensile stress at 800% elongation, 4°C (39.2°F) 500mm/mm rate of pull, kg/cm ²	2.0
Elastic recovery by means of ductilometer, %	58+

405.20 PREPARATION OF PAVEMENT

- A. Pavement surface - The pavement surface which is to receive the sealant must be sound, surface cured, and clean in order for the asphalt emulsion to perform properly.
- B. Cleaning surface - The asphalt pavement surface shall be swept and cleaned by the contractor prior to the application of the emulsion. To be clean, the surface shall be free from sand, grease, dirt, and other foreign matter. Cleaning shall include the removal of grass from all joints and/or cracks in the surface if they exist. The pavement will not be sealed until it has been cleaned entirely. Cleaning shall be accomplished by means of power blowers, stiff bristle brooms, vacuum unit, or by pressure flushing.
- C. Deleterious matter - Any accumulation of grease or oil shall be removed by scraping, burning, or scrubbing with detergent (if detergent is used, it must be thoroughly rinsed from the surface). If oil is still soaked into pavement but the pavement is sound as determined by the Engineer, such areas shall be coated with an acrylic oil spot primer to promote better adhesion and to prevent bleeding.

405.30 EQUIPMENT

Equipment for the application of the fog seal shall conform to Section 400.30 of these Standard Specifications.

405.40 APPLICATION OF MATERIALS

- A. Emulsion temperature - The application temperature of the emulsion shall be between 120°F and 160°F. The contractor must use a delivery system that is equipped with heating and circulation capability to ensure the proper mixing and even distribution of the material.
- B. Weather Conditions - The emulsion shall be applied when weather permits as described in section 400.40 of these Standard Specifications.
- C. Emulsion application rate - Apply sealer in one uniform coat with a mechanical distributor which has controlled rate capabilities and a spray wand. The application rate will be between 0.08 to 0.12 gallons per square yard of diluted material. The project Engineer or his designee will determine the actual application rate for each street.

- D. Sand Blotter application - On certain pavement surfaces, the emulsion may not penetrate or dry within a reasonable period of time. In such instances, if required by the Engineer, a sand blotter shall be placed on the surface of the roadway at a rate of approximately 1 to 2 pounds per square yard prior to opening the roadway to traffic. The sand must be uniformly spread across the surface.
- E. Protection of property - Any area that is not readily accessible for sealing by the distributor will be sealed with the use of squeegees, brooms, roller or spray wand. Any material sprayed or splattered on adjacent structures not intended to receive the seal coat shall be cleaned by the contractor at the time the over application occurs. Care shall be taken to prevent the spraying of the sealing material on that portion of pavement being used by traffic or areas not to be sealed. In the event that the sealant is splattered or picked up by traffic, it will be the contractors responsibility to remove and clean that material from the vehicles.
- F. Drying time - The contractor must not allow traffic to travel on the surface until it is entirely dry and no longer tacky.
- G. Time of application - Fog sealing will be applied only between the hours of 8:30 am and 2:30 pm. All streets must be capable of being opened to traffic by 4:00 pm.

405.50 TRAFFIC CONTROL

Traffic control responsibility - Traffic control must conform to the Manual of Uniform Traffic Control Devices or the traffic control plan provided for by specified contract documents, whichever is more stringent. The Contractor may be allowed to completely close the street to be sealed if traffic control is adequate and no two adjacent streets are closed at the same time.

405.60 NOTIFICATION OF PUBLIC

The contractor shall provide each residence and business with a notice of when their street is to be sealed at least 24 hours in advance of work being done. This will provide adequate lead time for residents to move vehicles from the streets. The notice to be distributed shall be provided by the City of Las Cruces. Towing of any vehicle(s) will be done through the City of Las Cruces. Notices must not be placed in mail boxes.

405.70 POST APPLICATION

After application of the sealer, depressions in the pavement that collect residual sealer and puddles should be spread to avoid a tacky slow curing surface. Any material spread, tracked, spilled, or distributed on areas not intended to be sealed will be cleaned and/or removed by the contractor before proceeding with sealing operations at other locations. These areas include but are not limited to gutters, curbs, sidewalks, driveways and ramps. Removal of sealant from concrete surfaces shall be done by the use of a steel bristled brush or other suitable method approved by the Engineer. The use of solvents will not be permitted.

If any areas are tracked or do not get properly sealed, the contractor will be required to go back to those areas and touch up the unsealed areas at his own expense.

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SECTION 410

REJUVENATION FOG SEAL

410.00 SCOPE

The work to be performed shall consist of furnishing required labor, material, equipment, parts and supplies necessary for application of an asphalt emulsion rejuvenating agent to restore asphalt pavements.

410.10 MATERIALS

- A. Rejuvenating Agent - The rejuvenating agent shall consist of a cationic emulsified asphalt that meets the requirements listed in TABLE 410-1. The Contractor shall furnish the Project Engineer certified shipping tickets showing the source and manufacturer of the material, the date manufactured, the date shipped, the location shipped to and the date received.
- B. Dilution - The dilution rate shall be two parts emulsion to one part water unless otherwise specified. When loading the distributor, the asphalt rejuvenating agent concentrate shall be loaded first and then the required amount of water shall be added.
- C. Water - Water shall be potable and free from any deleterious substances that may affect the stability of the emulsion.
- D. Submittals - The contractor shall furnish a certificate of compliance from the manufacturer stating that the rejuvenating material being supplied meets requirements of table 410-1 below.
- E. Sand Blotter - Sand blotter material shall be low to non-plastic. The sand blotter shall conform to Section 240 of these Standard Specifications. Sand shall be free flowing, dry, sharp, and applied at a rate necessary to blot excess material. The Contractor shall keep adequate sand with the distributor to cover accidental spills.

TABLE 410-1 REJUVENATING AGENT

TESTS	TEST METHOD		REQUIREMENTS	
	ASTM	AASHTO	MIN.	MAX.
TESTS ON EMULSION:				
Viscosity at 25°C, SFS	D-244	T-59	15	40
Residue, %w ¹	D-244 (Mod)	T-59 (Mod)	60	65
Miscibility Test ²	D-244 (Mod)	T-59 (Mod)	No Coagulation	
Sieve Test, %w ³	D-244 (Mod)	T-59 (Mod)	-	0.1
Particle Charge Test	D244	T-59	Positive	
TESTS ON RESIDUE FROM DISTILLATION:				
Flash Point, COC, °C	D-92	T-48	196	-
Viscosity at 60°C, cSt	D-445	-	100	200
Asphaltenes, %w	D-2006-70	-	-	1.0
Maltene Distribution Ratio $\frac{PC + A_1}{S + A_2}$ ⁵	D-2006-70	-	0.3	0.6
PC/S Ratio ⁵	D-2006-70	-	0.5	-
Saturated Hydrocarbons, S ⁵	D-2006-70	-	21	28

410.20 SURFACE PREPARATION

Surface preparation for the application of the rejuvenating agent shall conform to Section 400.20 of these Standard Specifications.

410.30 EQUIPMENT

Equipment for the application of the fog seal shall conform to Section 400.30 of these Standard Specifications.

410.40 APPLICATION OF MATERIALS

- A. Rejuvenating agent temperature - The application temperature of the rejuvenating agent shall be between 120°F and 160°F. The contractor must use a delivery system that is equipped with heating and circulation capability to ensure the proper mixing and even distribution of the material.

- B. Weather Conditions - The emulsion shall be applied when the ambient air temperature is 50°F and rising and there is no threat of rain for an eight hour period. The surface temperature must be at least 60°F and rising before the emulsion can be applied. The surface may be dry or damp but not wet when applying the rejuvenating agent. Material application shall cease if the wind velocity exceeds 12 MPH. The wind velocity shall be the velocity in miles per hour determined by the Projects Inspector by averaging the maximum and minimum wind velocity observed in any three (3) minute period prior to or concurrent to ongoing fog sealing operations. The wind velocity shall be measured three feet above the roadway surface.
- C. Rejuvenating agent application rate - Apply sealer in one uniform coat with a mechanical distributor which has controlled rate capabilities and a spray wand. The application rate will be between 0.09 to 0.11 gallons per square yard of diluted material. The project Engineer or his designee will determine the actual application rate for each street.
- D. Sand Blotter application - The sand Blotter shall be applied after the rejuvenating agent has penetrated into the asphalt for a minimum of 20 minutes. The sand must be uniformly spread across the entire roadway surface. The sand blotter shall be placed on the surface of the roadway at a rate of approximately 2 to 3 pounds per square yard. The sand must be uniformly spread across the surface.
- E. Protection of property - Any area that is not readily accessible for sealing by the distributor will be sealed with the use of squeegees, brooms, roller or spray wand. Any material sprayed or splattered on adjacent structures not intended to receive the seal coat shall be cleaned by the contractor at the time the over application occurs. Care shall be taken to prevent the spraying of the sealing material on that portion of pavement being used by traffic or areas not to be sealed. In the event that the sealant is splattered or picked up by traffic, it will be the contractor's responsibility to clean that material from the vehicles.
- F. Drying time - The contractor must not allow traffic to travel on the surface until the sand has been spread and rolled.
- G. Rolling - The entire treated asphalt surface must be rolled with a pneumatic tired roller a minimum of 3 passes immediately after the sand blotter has been placed. A pass shall be defined as travel of the roller from one end of the street to the other parallel to the longitudinal construction joints. The roller must cover the entire surface of the sealed surface a minimum of three times.
- H. Time of application - Fog sealing will be applied only between the hours of 8:30 am and 2:30 pm. Sand blotter may be applied after 2:30 pm if needed. All streets must be capable of being opened to traffic by 4:00 pm.

410.50 TRAFFIC CONTROL

Traffic control responsibility - The contractor will be responsible for providing all of the traffic control. Traffic control must conform to the Manual of Uniform Traffic Control Devices or the traffic control plan provided for in this contract document, whichever is more stringent. The Contractor may be allowed to completely close the street to be sealed if traffic control is adequate and no two adjacent streets are closed

at the same time.

Traffic control will be required for sealing, sanding, and rolling operations.

410.50 NOTIFICATION OF PUBLIC

The contractor shall provide each residence and business with a notice of when their street is to be sealed at least 24 hours in advance of work being done. This will provide adequate lead time for residents to move vehicles from the streets. The notice to be distributed shall be provided by the City of Las Cruces. Towing of any vehicle(s) will be done through the City of Las Cruces. Notices must not be placed in mail boxes.

410.60 POST APPLICATION

- A. After application of the sealer, depressions in the pavement that collect residual sealer and puddles should be spread to avoid a tacky slow curing surface. Any material spread, tracked, spilled, or distributed on areas not intended to be sealed will be cleaned and/or removed by the contractor before proceeding with sealing operations at other locations. These areas include but are not limited to gutters, curbs, sidewalks, driveways and ramps.
- B. Removal of sealant from concrete surfaces shall be done by the use of a steel bristled brush or other suitable method approved by the Engineer. The use of solvents will not be permitted.
- C. If any areas are tracked or do not get properly sealed, the contractor will be required to go back to those areas and touch up the unsealed areas at his own expense.
- D. The Contractor shall be responsible for sweeping and cleaning streets to the satisfaction of the Project Inspector before and after the surface treatment. The entire road surface to be treated as well as curb and gutters shall be cleaned of water, earth, leaves, dirt, and foreign material. A mechanical self propelled pick up type sweeper shall be required to complete the sweeping and cleaning in a timely manner.
- E. Every street on this project shall be swept within 24 hours from completion of the rolling operations. Every street shall be swept entirely one more time before the project is accepted.

SECTION 415

ASPHALT PAVEMENT SEALER

415.00 DESCRIPTION

This work shall consist of an application of a rubberized premixed asphalt emulsion blended with select mineral fillers and non-asbestos fibers to a pavement as a surface seal with a non-slip surface.

415.01 MATERIAL

- A. Emulsified Asphalt. Emulsified asphalt used in the sealer shall be Anionic SS-1, SS-1H, CSS-1, CSS-1H, OR HFE-90 through 120.
- B. Mineral Filler. Mineral filler shall be clean, minus 30 mesh sand, colloid clay, powdered slate (minus 40 mesh). There shall be a minimum of 13% mineral filler unless otherwise specified.
- C. Fiber. Fiber shall be non-asbestos cellulose.
- D. Enhancers. Enhancers shall be liquid latex, acrylic, and/or other materials approved by the Engineer. A minimum of 1% shall be used unless otherwise specified.
- E. Water. Water shall be clear, potable, and compatible with the sealer.
- F. ASTM D 217, Cone Penetration at seventy-seven degrees F (77°F). minimum 30 mm , maximum 120 mm.
- G. AASHTO T-45, fifty-six percent (56%) non-volatile, soluble in Trichloroethylene by weight.

415.02 SURFACE PREPARATION

The surface to which the sealer is to be applied shall be clean of all dirt, sand, oil, or grease. Dirt in cracks shall be blown out with compressed air and filled with an approved emulsion mixture. The surface shall be cleaned by brooming the area to be sealed to remove all foreign material. Oil spots shall be cleaned with detergent and water then sealed with SS1H or an approved oil spot sealer.

415.03 DEPRESSIONS AND POT HOLES

All major depressions and "pot holes" shall be repaired using hot or cold mixed asphalt. All cracks over one-half inch (1/2") in width shall be filled with an approved crack filler after being cleaned with compressed air. Prior to being filled with a crack filler, cracks shall be primed with an approved asphalt emulsion.

415.04 APPLICATION OF SEALER

Sealer shall be applied by a spreader box equipped with squeegees. Sealer shall be applied at the rate

recommended by the manufacturer but not less than 0.15 gallons per square yard. The material shall be applied in two layers each completely covering the surface.

415.05 WEATHER LIMITATIONS

Shall meet the requirements of Section 300.08.

415.06 UTILITY ACCESS COVERS

Contractor shall be required to cover all utility access covers with construction paper or other suitable means of keeping all sealant from the cover. All materials splattered or splashed on the covers will be promptly removed by the contractor.

415.07 JOINTS

The contractor shall provide a straight edge at all intersections and cross streets as well as all longitudinal joints. The edge of the sealed area shall be perpendicular to the direction of travel and shall not extend beyond the edge of the asphalt pavement.

SECTION 420

POLYMER MODIFIED SLURRY SEAL

420.00 DESCRIPTION

The bituminous slurry surface shall consist of properly proportioned and mixed mineral aggregate, asphalt emulsion and water, spread evenly on roadway surfaces as specified herein and as directed by the Engineer. The slurry when cured shall have a homogeneous appearance, fill cracks, adhere firmly to the adjacent surface, and have a skid resistant texture.

420.10 MATERIALS

- A. Asphalt Emulsion: The Emulsified Asphalt shall be quick - setting polymer modified CQS-1H(P) or QS-1H(P). The minimum amount and type of polymer modifier shall be determined by the laboratory performing the mix design. This minimum amount will be based on the weight of the bitumen and will be certified by the emulsion supplier. The emulsion shall be modified with the polymer prior to emulsification. The emulsified asphalt shall conform to the following specifications: (Residual asphalt 7.5 TO 13.5% by weight of total aggregate by extraction)

TEST ON EMULSION	MINIMUM	MAXIMUM
Viscosity, 77°F, SSF	15	90
24-hour Storage Stability	-----	1
Sieve test, %	-----	0.3
Residue by Distillation to 400°F	57	-----
TEST ON RESIDUE FROM DISTILLATION:	MINIMUM	MAXIMUM
Penetration, 77°F, 100g., 5 sec.	40	90
Solubility in Trichloroethylene	97	-----
TESTS FOR ELASTICITY:	MINIMUM	MAXIMUM
1. Force Ratio (f_2/f_1), 39.2°F, f cm/min. 30 cm elongation	0.2	-----
Elastic Recovery by means of Ductilometer, 77°F, %	45	-----

Notes:

Force Ratio Determination by Ductilometer method Line item in specification: Force Ratio (f_2/f_1), 39.2°F, 5 cm/min., 30cm elongation. The Force Ductility tests follows procedures as specified in

ASTM D113 with the following conditions and modifications:

- a. Temperature - 39.2°F
- b. Rate of travel - 5 cm/min.
- c. The standard V shaped sides for the specimen mold are replaced by straight sided inserts of the same length, such that the specimen will contain a section 1 cm by 3 cm.
- d. A calibrated force adapter is placed on one end of the specimen mold, so that the tensile force can be determined at any point during the elongation.

The Force Ratio is defined as the force at 30 cm elongation (f_2) divided by the maximum force at the initial peak (f_1).

- B. Aggregate. The mineral aggregate used shall consist of gravel, manufactured sand, stone, slag, crusher fines, and others, or a combination thereof. The aggregate shall be 100% crushed.

The aggregate shall be clean and free from organic matter and other deleterious substances. The aggregate shall meet the following :

QUALITY	TEST METHODS		SPECIFICATIONS
	ASTM	AASHTO	
SAND EQUIVALENT	D-2419	T-176	55 min.
SOUNDNESS	C-88	T-104	15% max. using NA_2SO_4 or 25% max. using $MGSO_4$
ABRASION WEAR	C-131	T-96	35% max.

Mineral fillers such as Portland cement, limestone dust, lime, fly ash and others shall be considered as part of the blended aggregate, shall be used in the minimum amount required. The additives shall meet the gradation requirements of AASHTO M-17 or ASTM D-242.

The total aggregate, including the mineral filler, shall conform to the following gradations when tested by ASTM C-136 or AASHTO T-27.:

SIEVE SIZE	PERCENT PASSING	TOLERANCE
3/8"	100	± 7 %
NO. 4	90-100	± 7 %
NO. 8	65-90	± 4 %

NO. 16	40-70	± 4 %
NO. 30	25-50	± 4 %
NO. 50	18-30	± 4 %
NO. 100	10-21	± 4 %
NO. 200	5-15	± 2 %

- C. Water. Water is an important element in the slurry mixture and should be clear, potable, and compatible with the slurry mixture.

420.20 MIX DESIGN REQUIREMENTS

The Contractor shall prepare a mix design for the slurry seal. The mix design will be submitted to the Project Manager for approval five (5) days prior to any work being accomplished. The mix design will include the following information:

- A. Aggregate gradation;
- B. Additive to be used if needed, percentage by weight of aggregate;
- C. Asphalt percentage and type (tolerance ± 0.2%);
- D. Sand equivalent of aggregate;
- E. Setting time (40 minutes max);
- F. Water resistance test results; pass or fail;
- G. Results of Wet Track Abrasion Test (max lost of 75 grams per ft².); and
- H. Compatibility of the aggregate and emulsion must be verified by the mix design.
- I. The component materials shall be within the following limits:

RESIDUAL ASPHALT	7.5% to 13.5% by dry weight of aggregate.
MINERAL ADDITIVE	0% to 3% by dry weight of aggregate.
ADDITIVE	As required to provide the specific mixing and setting properties.

WATER	As required to produce proper mix consistency and setting properties. The effect of moisture content on the specific weight of aggregate being used shall be taken into account in calibrating the machine to deliver asphalt in the correct proportion.
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All materials shall be pretested by the Contractor at his expense as to their suitability for use in slurry sealing and conformance to these specifications.

The laboratory report shall show the results of tests performed on the individual materials, comparing their values to those contained in this specification.

At a minimum the report will provide the following information on the slurry seal mixture:

TEST PURPOSE	METHOD	SPECIFICATION
SLURRY SEAL CONSISTENCY	ISSA T-106	2-3 cm
WET STRIPPING TEST	ISSA T-114	90-100% coated surfaces
COMPATIBILITY	ISSA T-115	pass at 100°F
EXCESS ASPHALT LOADED WHEEL	ISSA T-109	50 g/ft ² max.
WET TRACK ABRASION	ASTM D-3910	75 g/ft ² max.
COHESION TEST	ISSA T-139	12 kg-cm at 30 minutes, 16 kg-cm at 1 hour.

420.30 SURFACE PREPARATION

- A. Immediately prior to applying the slurry seal, the contractor shall clean the surface by sweeping, flushing, or other means necessary to remove all loose particles and dirt from the surface.
- B. All debris and material removed from the site shall be disposed of at the contractor's expense at a site approved by the engineer.
- C. All utility access covers shall be covered prior to the slurry operation with plastic bags or other suitable material to prevent the slurry material from coating the covers. The covers shall be cleaned of all slurry material before the roadways will be accepted.
- D. Any material inadvertently spilled, splashed, tracked, or otherwise placed on structures such as sidewalks, curbs, gutters, or driveways shall be immediately cleaned by the contractor at his expense.

420.40 APPLICATION OF SLURRY SEAL

- A. General. During the placing procedure, a close watch must be kept on the spreader box to ensure that the slurry is rolling in one continuous mass and is evenly distributed across the box to the end of a pass. A problem may arise with even distribution when placing slurry in areas of high crown or on super-elevated curves. The slurry should be constantly diverted to the high side of the box, as gravity will keep the low side filled. When approaching the end of a pass, the operator should cut the machine off in time to have as little slurry left in the mixer as possible and none left in the spreader past the finish line. Overmixing, whereby trapped air and overbeating of the emulsion causes a puffy, malt-like appearance, can occur if, at the end of a pass, the operator fails to shut off the mixer with the slurry still inside. If the surface is being pre-wetted by water fogging, the spray bars must be cut off to prevent puddles any time the slurry machine stops and restarted when the operation proceeds.

Grades of eight percent (8%) or more call for some adjustment in the slurry mixture. The adjustment differs depending on whether the direction of placing is uphill or downhill.

1. Uphill Placing. It is easier to hold the slurry in the spreader box because the direction of movement forces it through two (2) sets of squeegees before it leaves the box. Therefore, a more fluid slurry is used to avoid placing a thick layer.
 2. Downhill Placing. A slurry of ordinary consistency often will overflow, push out under the front squeegee, or both, and flow ahead of the machine. Consequently, it must be thickened somewhat for downhill operations.
- B. Joints. There are two (2) acceptable times for making a joint--when the slurry is still in a completely uncured, semi-fluid condition, or in a completely cured condition. The time in between these two (2) conditions the contractor may not work a joint because of possible tearing and scarring. When making both transverse and longitudinal joints with this latter condition, the area overlapped should be *lightly* wetted just ahead of the box being dragged over (hand hose or spray bar).
- C. Handwork. This type of slurry placement should be minimized as much as possible, but there will always be some fill-in and small areas of repair requiring handwork. The area to be handworked should first be lightly dampened with the slurry machine hand hose and the slurry worked immediately and quickly after dumping into small piles. With quick-set slurry, the time for working the mix is particularly critical.
- D. Traffic Control. Traffic control shall conform to the traffic control plan prepared for this specific project. As a minimum, the traffic control must conform to the Manual of Uniform Traffic Control Devices (MUTCD). Streets may be closed and barricaded by the contractor if prior approval has been given by the Engineer.
- E. The minimum yield for the Type II Polymer Modified Slurry seal shall be 15 pounds per square yard.

420.60 EQUIPMENT

Slurry Machine. The slurry machine shall be a travel type mixing plant which shall be self propelled and truck mounted. The machine must have separate tanks for emulsified asphalt and water along with pumps for these materials. The aggregate must be volumetrically controlled by feeding it from a hopper by an approved system capable of being calibrated, counted, and monitored at all times.

The slurry machine must have a continuous flow mixing unit, either single or double pugmill, capable of accurately delivering a predetermined proportion of aggregate, emulsified asphalt, and water to the mixing chamber and discharging the thoroughly mixed slurry on a continuous basis. The mixing unit must also include a metering device or method that introduces, if needed, a predetermined proportion of mineral filler into the mixer at the same time the aggregate is fed. The spreader box must be equipped with a mechanical distribution device such as an auger to evenly distribute material to all portions of the spreader box.

420.70 WEATHER LIMITATIONS

Slurry sealing shall not be placed on a surface that is excessively wet or if weather conditions threaten the curing and setting of the material. The surface temperature must be at least 45°F and rising at the time of placement. Work shall cease when the chill factor is below 45°F. The chill factor is defined as the ambient air temperature in degrees fahrenheit minus the wind velocity in MPH.

The wind velocity shall be the velocity in MPH determined by the average of the maximum and minimum wind velocity observed in any three minute period immediately prior to or concurrent with ongoing slurry operations. The wind velocity shall be measured at 5 feet above the ground level.

SECTION 425

BITUMINOUS SURFACE TREATMENT

425.00 DESCRIPTION

This work shall consist of a bituminous wearing surface composed of applications of asphaltic material covered with aggregate, constructed on various roadway surfaces.

There are three types of bituminous surface treatments each with their own specific requirements as outlined herein.

TYPE ONE - Single Penetration with fine aggregate.

TYPE TWO - Single Penetration with coarse aggregate.

TYPE THREE - Double Penetration; coarse on first lift and fine on the second.

425.10 TEMPERATURE LIMITATIONS

The surface treatment shall not be applied when the air temperature is below 70°F and falling, but may be applied when the air temperature is above 60°F and rising. Air temperature shall be taken in the shade and away from artificial heat. The surface temperature of the area to be treated shall be at least 60°F.

Asphaltic material shall not be placed when weather conditions are not suitable as determined by the Engineer.

425.20 MATERIALS

1. Aggregate:

- A. The aggregate shall be a crushed stone or gravel, composed of hard durable fragments that meet the requirements outlined in Table 1.0.
- B. Seventy-five percent (75%) by weight of all plus No. 4 material shall have a minimum of two (2) mechanically fractured faces.
- C. When tested for soundness by use of Magnesium Sulfate as described by AASHTO T-104 the loss in five (5) cycles shall not be more than eighteen percent (18%)

Table 425.20 GRADATION AND APPLICATION RATES

SIEVE	TYPE I	TYPE II
5/8"	100	100
1/2"	100	95-100
3/8"	95-100	-
No. 4	0-10	0-12
No. 10	0-2	0-2
No. 200	0	0
AGGREGATE APPLICATION RATE	15-18 POUNDS PER YD ²	28-30 POUNDS PER YD ²
ASPHALT APPLICATION RATE	0.29-0.31 GAL. PER YD ²	0.39-0.41 GAL. PER YD ²

2. Asphaltic Material:

- A. The asphalt material to be used for the bituminous surface treatments under this specification shall be one of the following:
 - * RS-1, RS-2, HFRS-2, or HFE-100P if an anionic emulsified asphalt is used.
 - * CRS-1 or CRS-2 if a cationic emulsified asphalt is used.
 - * Other grades of asphaltic materials may be used if approved by the Engineer.
- B. Unless otherwise specified, the type of asphalt emulsion to be used shall be HFE-100P or equivalent and shall conform to the requirements listed in table 2.0.

TABLE 2.0 ASPHALT EMULSION

TEST	RESULT
Viscosity, saybolt Furol, at 122°F, sec.	50+
Sieve test (No. 20 sieve), % retained	0.10-
24 Hour storage stability, %	1.0-
Coating test; 3 min.	stone coated thoroughly
Demulsibility, 35 ml 0.02n CaCl (2)	40+
Distillation test: Residue from distillation test to 400°F., %	65+
Oil distillate, by volume %	2.0-

Characteristics from dist. test to 400°F., Penetration at 77°F., 100g. 5 sec., 50g., 5 sec. *	90-150
Float test at 140 °F, sec	1200+
Tensile stress at 800% elongation, 4°C (39.2°F); 500 mm/mm rate of pull, kg/cm ²	2.0+
Elastic recovery by means of ductilometer, %	58+
Ductility, 77 deg.F.,cm	125 min.

425.30 EQUIPMENT:

The equipment used by the contractor shall include the following:

1. Self propelled rotary power broom or mobile pickup broom for pavement cleaning and excess aggregate removal.
2. Self propelled asphalt distributor equipped with a full circulating spreader bar and a pump system capable of applying asphaltic material within ± 0.05 gallons per square yard tolerance of the specified application rate. The distributor shall be capable of distributing the specified material uniformly over the entire area to be sealed. The distributor must also have a tachometer, pressure gauge, volume measuring device, and a thermometer capable of accurately measuring the stated variables.
3. The cover material (chip) spreader shall be self propelled with an aggregate receiving hopper in the rear, belt conveyors to carry the aggregate to the front, and a spreading hopper equipped with a full-width distributor auger and spread roll. The spreader shall be in good mechanical condition and be capable of applying the cover material uniformly across the spread at the rate specified.
4. Pneumatic tired rollers shall carry a minimum loading of 3,000 pounds on each wheel and a minimum air pressure of 85 pounds per square inch in each tire.
5. The trucks for hauling the cover aggregate shall be tailgate discharge and shall be equipped with a device to lock onto the hitch at the rear of the material aggregate spreader. Haul trucks shall also be compatible with the aggregate spreader so that the dump bed will not push down on the spreader when fully raised or have too short of a bed which results in aggregate spillage while dumping into the receiving hopper.

425.40 CONSTRUCTION

1. All holes, depressions and surface irregularities must be removed or treated in a method satisfactory to the Engineer prior to any aggregate surface treatment. On existing asphalt surfaces, all cracks which are 1/2" wide and above shall be cleaned and sealed with an asphalt crack sealant. Emulsion and sand of the same grade and type as the chip seal will be acceptable for crack sealing.
2. Immediately prior to applying the asphaltic material, the surface shall be cleaned by sweeping, flushing,

or other means necessary to remove all loose particles of pavement, all dirt, and all other extraneous material. Pavements impregnated with grease, oil, or fuel shall be thoroughly scrubbed with water and an approved detergent and then flushed and swept clean.

3. The asphaltic material shall not be applied until an Inspection of the surface has been made by the Engineer or his Designee, and it is determined that the surface is suitable for the application to begin.
4. The contractor shall remove and dispose of all rubbish and excess materials in a manner that will prevent spillage on streets or adjacent areas. Clean up of spillage and rubbish will be at the contractor's expense and disposed of at a site approved by the Engineer.
5. The asphaltic material must be applied at a temperature of 140°F to 160°F or as specified by the Engineer.
6. Cover aggregate shall be immediately applied to the asphaltic material after spreading at a rate as described in Table 1.0 of these specifications or as directed by the Engineer.
7. After the aggregate has been spread upon the asphaltic material, any piles, ridges, or uneven aggregate distribution shall be carefully removed to eliminate bumps or depressions in the completed surface before the surface is rolled. Additional aggregate shall be spread in quantities necessary to prevent picking up by rollers or traffic.
8. Excess aggregate which in the opinion of the Engineer are not salvageable shall be removed and disposed of by the contractor at the contractor's expense.
9. An adequate amount of rollers shall be used to accomplish the required embedment of the aggregate. Sufficient rollers shall be used for the initial rolling to cover the width of the aggregate spread in one pass. The first pass shall be made immediately behind the aggregate spreader. If the spreading is stopped for an extended period, the aggregate spreader shall be moved ahead or off to the side to allow all placed aggregate to be immediately rolled. Four complete passes with the rollers shall be made with all rolling completed within one hour after the application of the aggregate cover material. In all areas not accessible to the rollers, the aggregate shall be adequately compacted with hand tampers which must not weigh less than 25 pounds and have a face area of not more than 50 square inches.

There must be a minimum of one steel roller for the initial rolling and one pneumatic roller for secondary rolling. There must be a minimum of two rollers for each chip spreader in operation.

425.50 FLUSH COAT SEALING (OPTIONAL)

1. All streets to be chip sealed shall receive a flush coat (fog seal) after the chip seal has ample time to cure and be swept.
2. The contractor shall apply a film of High Float Emulsion (HFE-100P) at the rate of 0.10 to 0.12 gallons per square yard.
3. The flush coat material shall be HFE-100P cut back with water to a 1:1 dilution (oil:water) complete in

place. NOTE! THE DILUTION OF THIS MATERIAL MUST BE DONE BY THE MATERIAL MANUFACTURER/SUPPLIER. THE DILUTION OF THIS MATERIAL MUST NOT BE ATTEMPTED USING ANY LOCAL WATER SOURCE.

4. The contractor shall seal the streets in a neat workmanlike manner and avoid splattering material on adjacent surfaces not to receive the seal coat. Paper will be required on all joints as required for the chip seal.

425.60 SPECIAL TRAFFIC REQUIREMENTS

1. All traffic including hauling equipment shall be kept off the newly applied aggregate surface until it has been completely rolled. During construction, any traffic on the newly applied surface (after rolling), including hauling equipment, shall be minimal and limited to 10 MPH in areas where it is impossible to avoid.
2. The contractor must furnish a minimum of two "loose gravel" signs for each street under construction and shall comply with the Manual of Uniform Traffic Control Devices.

425.70 CLEANING PROTECTING AND SWEEPING

1. Any aggregate that becomes coated or mixed with dirt or any other foreign matter shall be removed, replaced with clean aggregate, and rerolled, as directed by the Engineer.
2. All surplus aggregate shall be swept off the surface and gutters and removed. This material will be included in the "actual quantity" of material placed and must be disposed of on City property as directed by the Engineer. The final clean up shall include removal of all aggregate from all storm water catch basins and inlets.
3. All storm water catch basins, drop inlets, gratings, manhole covers, water valve boxes, and all other utility access covers shall be covered during the spraying and spreading operations. These covers shall be cleaned and remain accessible within 24 hours of completion of the sealing operation.
4. The contractor shall clean splattered, splashed, or tracked asphalt materials from all curb and gutter and other improvements not to receive the seal coat.
5. All transverse joints will be started and completed on building paper or other suitable material to provide a straight edge.
6. Each Street shall be lightly swept between 24 and 48 hours after the chip seal has been applied. The contractor shall have a mechanical broom available to sweep the streets at an earlier time if the need arises. The contractor shall be responsible for the project site until all excess aggregate has been cleaned and removed from the project area.

425.80 CONDITIONS FOR TYPE III SURFACE TREATMENTS

A Type III chip seal will be a Type II covered by a Type I Chip Seal. The contractor shall be responsible for the maintenance of the surface of the first course until the second course is applied. All Type II streets on the project list shall receive a Type I seal over the top.

SECTION 430 CRACK SEALING OF ASPHALT PAVEMENTS

430.00 SCOPE

This work shall consist of routing and cleaning cracks on asphalt pavement then sealing them with rubberized asphalt in substantial compliance with these specifications, ASTM D3405, and as directed by the Project Engineer.

435.10 MATERIAL

Rubberized asphalt cement crack filler shall meet the requirements listed in ASTM D3405. The crack filler must contain a minimum of 18% recycled rubber by weight of the asphaltic components.

The joint sealant shall be composed of materials that will form a resilient and adhesive compound capable of effectively sealing joints in asphalt pavements against the infiltration of moisture and foreign material throughout repeated cycles of expansion and contraction with temperature changes, and that will not, at ambient temperatures, flow from the joint or be picked up by vehicle tires. The material shall be capable of being brought to a uniform pouring consistency suitable for completely filling the joints without inclusion of large air holes or discontinuities and without damage to the material. It shall remain relatively unchanged in application characteristics for at least 6 hrs at the recommended pouring temperature in the field.

The rubberized crack filler shall be accepted by certification from the asphalt rubber supplier. The contractor shall furnish the Project Engineer with the material composition certification not later than ten (10) days before initiating the crack sealing operations.

The crack sealing material shall conform to the following physical parameters:

PARAMETER	REQUIREMENT
Penetration - at 77°F (25°C), 150 g, 5s	Shall not exceed 90
Flow - at 140°F (60°C)	Shall not exceed 3.0 mm
Bond - Sealant shall be tested at -20°F (-29°C) for 3 cycles.	ASTM D 3405-78; section 4.4
Resilience - at 77°F (25°C)	Minimum recovery of 60%.
Asphalt Compatibility	ASTM D 3405-78; section 4.6

430.20 CONSTRUCTION REQUIREMENTS

1. Equipment. The equipment used in the mixing, heating, and application of the asphalt-rubber material shall conform to the following:

The equipment used for the application of the material shall be capable of maintaining a continuous uniform, homogeneous mixture throughout the sealing operation. The equipment shall incorporate a mechanical mixing device within the heating unit such that a continuous mixing of the sealant is maintained. Excessive heating, reheating, or heating for a long period of time will not be permitted due to potential damage to the material.

The material must be heated in a kettle or melter constructed as a double boiler, with the space between the inner and outer shells filled with oil or other heat-transfer medium. Positive temperature control, mechanical agitation, and recirculating pumps shall be provided. Direct heating will not be permitted.

The Project Engineer must be satisfied that the material and the application process proposed have been successfully used in similar circumstances on comparable projects.

Nozzles and hoses shall be of adequate design and size to provide for uniform application of the asphalt-rubber material without clogging or other irregularities in distribution. Operations shall cease if it is determined by the Project Engineer that there are irregularities in the distribution of the material. Defective equipment shall be removed from the project.

2. Weather Limitations. Asphalt Rubber crack sealant shall not be placed unless the atmospheric temperature is at least 40 degrees Fahrenheit and rising. The sealant shall not be placed on wet surfaces or if there is a threat of rain. The Project Engineer shall determine if the surface is such that sealing will not be threatened by existing moisture. If rain or moisture penetrates into cracks, there will be a minimum of 48 hours required for the cracks to dry naturally. Artificial methods of drying cracks may be used only if approved by the Project Manager.
3. Mixing. The percentage of granulated crumb rubber by weight of the asphalt cement shall be as determined and specified by the material manufacturer. The temperature of the asphalt cement shall be as listed on the material safety and certification sheets and as recommended by the material manufacturer.
4. Application of the Asphalt-Rubber Crack Sealant. Application of the material shall be made when the weather conditions are such that a satisfactory seal can be achieved and the surface is in a dry condition. The material will be applied to one lane at a time to provide access for vehicular traffic.
5. Routing of Cracks. All cracks having an average clear opening of less than 1/2 inch shall be routed to provide a minimum sealant reservoir of 1/2 inch wide by 1/2 to 3/4 inch in depth.

All cracks having an average clear opening of 1/2 inch and greater will not be routed but shall be cleaned and blown out to a minimum of 1/2 to 3/4 inch in depth.

All cracks designated by the Project Engineer shall be routed. The router shall be centered over the crack and shall be equipped with a bit that is wide enough to cover the crack being routed (1/2 inch minimum) and 1/2 to 3/4 inch in depth.

Prior to placing the sealant into the cracks, they must be cleaned of all loose particles, dust and other deleterious substances by means of high velocity compressed air.

Only Asphalt-Rubber sealant shall be used to fill the routed, clean cracks. Care must be taken to avoid excess filling of the cracks. The top surface of the crack(s) shall be filled approximately 1/8 to 1/4 of an inch below the adjacent asphalt surface. Any material emanating above the surface shall be lapped or squeegeed off to provide a finished surface equal to or below the adjacent surfaces.

6. Traffic Control. Traffic control must conform to the Manual Traffic Control Devices. One lane shall remain open at all times. No vehicular traffic will be permitted on the sealant until sufficient time has elapsed for the material to become non-tacky.

430.30 CLEANING

All materials and debris emanating from this project shall be cleaned and removed from public and private property, including but not limited to sidewalks, driveways, lawns and roadways. Streets must be cleaned in their entirety within 24 hours of the sealing operation.

430.40 MATERIAL STORAGE

All crack sealing material must be stored in a secured storage area that will be made accessible to City Inspectors at all times. The contractor will be required to provide copies of all material haul tickets and certificate of compliance. The contractor will be required to complete and submit daily field reports detailing the quantities of materials placed on a street by street or site by site basis.

430.50 SUBMITTALS

A submittal detailing the material to be placed must be submitted for approval by the Engineer before the project begins.

430.60 MEASUREMENT AND PAYMENT

Asphalt Rubber crack sealant will be measured by the pound of applied sealant. Payment will be made at the contract unit price to include materials and the application of the material which includes the routing of the cracks, applying the sealant, leveling the surface, cleaning the street, and traffic control as well as all other incidental items.

The City will have a representative keep track of the quantities of materials used on a daily basis.

Unless otherwise specified, traffic control will be included in the unit price for placement of the material by the pound.

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SECTION 500

PORTLAND CEMENT CONCRETE AND CONCRETE RELATED MATERIALS

500.00 SCOPE

This specification shall be used for the supply and production of portland cement concrete and concrete related materials for the construction of concrete sidewalks, curb and gutter, valley gutter, ramps, footings for walls (all types), and other purposes as called for in the plans and specifications.

500.05 AGGREGATE

The fine aggregate shall conform to the requirements of ASTM Designation C 33. The coarse aggregate shall conform to ASTM C 33, size number 57, one inch to No.4, unless otherwise directed by the Engineer or unless clearance dimensions as hereinafter described govern.

If required, the Contractor shall furnish test certificates confirming that the aggregates meet all of the above requirements for fine and coarse aggregates as applicable to the job design mix.

500.10 WATER

Water used in mixing mortar, grout, and concrete or for curing concrete or for washing concrete aggregates shall be clear, free from oil, salt, sugar, vegetable matter, or other deleterious material; and shall have a pH value of not less than pH 4.5 or more than pH 8.5, as determined by AASHTO Standard Method of Test T 26, "Quality of Water to be Used in Concrete".

500.15 AIR ENTRAINMENT

Air-entraining admixtures for Portland Cement Concrete shall conform to the requirements of ASTM Designation C 260, "Specifications for Air-Entraining Admixtures for Concrete," as tested in accordance with ASTM C 233, "Method of Testing Air-Entraining Admixtures for Concrete".

500.20 ACCELERATING, RETARDING, AND WATER-REDUCING ADMIXTURES

Water-reducing admixtures, retarding admixtures, accelerating admixtures, water-reducing and retarding admixtures, water-reducing and accelerating admixtures, if used, shall conform to ASTM Designation C 494, "Specifications for Chemical Admixtures for Concrete". All admixtures except air-entrainment agents are prohibited unless approved by the Engineer. Calcium chloride is prohibited as an admixture in any concrete mixture for City projects. Prior to approval of any admixture, the Contractor shall submit a design mix demonstrating that the admixture is compatible with local materials and will accomplish the desired end results.

500.25 MIX DESIGN

1. The strength requirements for any particular design shall be based on the appropriate proportions of Portland cement, water, fine and coarse aggregate. Unless otherwise specified in the plans or specifications any concrete placed within the City right-of-way or in any City project shall attain a strength of 3,000 psi in 28 days and shall have a slump of three to five inches (3 to 5") and may be reduced to one half to two ($\frac{1}{2}$ to 2") for slip form pavers if prior authorization is given by the Engineer.
2. The aggregate proportions shall produce a workable mix, with coarse aggregate used in the greatest amount consistent with required workability. Field deviations from design mix proportions shall be made only with the written approval of the Engineer.
3. Concrete exposed to weathering shall have an air entrainment of three to five percent (3-5 %).
4. The maximum size of the aggregate shall not be larger than one-fifth ($\frac{1}{5}$) of the narrowest dimensions between sides of the forms within which concrete is to be poured or larger than three-fourths ($\frac{3}{4}$) of the minimum clear spacing between reinforcing bars, or between reinforcing bars and form.
5. For unreinforced slabs, the maximum size of aggregates shall not be larger than one-third ($\frac{1}{3}$) the slab thickness.
6. When requested, certificates of compliance, mill reports, or laboratory test reports assuring compliance with these specifications shall be furnished by the Contractor before incorporating materials into the work.

500.30 READY MIXED CONCRETE

Ready-mixed concrete shall be mixed and delivered in accordance with the requirements set forth in "Specifications for Ready-Mixed Concrete" (ASTM C 94), Alternative No. 2, except that a copy of all certificates and statements required by the ASTM C 94 Specification shall be provided to the Engineer by the Contractor. When ready-mixed concrete is used, and unless otherwise specified, the supplier shall be required to provide concrete based on the following furnished information:

1. Minimum cement content in bags per cubic yard of concrete, or equivalent units.
2. Surface-dry weights of fine and coarse aggregate.
3. Designated size, or sizes, of coarse aggregate.
4. Minimum strength requirements in p.s.i. in 28 days.
5. Slump desired at the point of delivery.
6. When air-entraining concrete is required, the maximum and minimum limits for air content of samples taken from the transportation unit at the point of discharge.

- The type of admixture, if used, other than air-entrainment, and the amount of admixture to be added per cubic yard of concrete mix.

500.35 STEEL REINFORCEMENT

- General. Unless otherwise indicated on the plans and by a special provision(s) within the specifications, all steel reinforcing used in Portland Cement Concrete shall conform to the following ASTM Designation Standards:

ITEM	ASTM DESIGNATION	ASTM TITLE
Steel Bars - deformed, minimum intermediate grade	A615	Billet Steel or Axle Steel Bars for Concrete Reinforcement of structural grade.
	A615 Grade 40	Deformed bars of Intermediate grade with 40,000 psi min. yield strength.
	A615 Grade 75	High-Strength Billet Steel Bars for Concrete Reinforcement with 75,000 psi min. yield strength.
	A615 Grade 60	Deformed Billet Steel Bars for Concrete Reinforcement with 60,000 psi min. yield strength.
	A615	Minimum Requirements for the Deformation of Deformed Steel Bars for Concrete Reinforcement.
Wire Mesh Reinforcement	A185	Welded Steel Wire Fabric for Concrete Reinforcement.

Support chairs for reinforcement may be metal or plastic.

- Shop Drawings. Shop drawings for reinforcing steel shall be submitted in duplicate to the Engineering Department.

500.40 WELDED WIRE FABRIC

Welded wire fabric shall be of the size and type as shown on the plans and shall conform to the requirements of ASTM Designation A 185.

500.45 JOINT SEALING MATERIALS

- Preformed expansion joint filler shall conform with the requirements of ASTM D 1751, "Specifications for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding

and Resilient Bituminous Types)" or D 1752, "Specifications for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Non-bituminous Types)," either alternate as tested in accordance with ASTM Designation D 545 "Methods of Testing Preformed Expansion Joint Fillers for Concrete (Non-extruding and Resilient Types)".

2. Hot-applied type joint sealing material shall conform with ASTM Designation D 1190, "Specifications for Concrete Joint Sealer, Hot-poured Elastic Type" as tested in accordance with ASTM Designation D 1191, "Method of Testing Concrete Joint Sealers".
3. Cold-applied type joint sealing material for ordinary applications (single or multiple-component type) shall conform with ASTM Designation D 1850, "Specifications for Concrete Joint Sealer, Cold Application Type," as tested in accordance with ASTM Designation D 1851, "Method of Testing Concrete Joint Sealer, Cold-Application Type".

500.50 CURING MATERIALS

1. Water used for curing concrete shall conform to the requirements hereinbefore stated in these specifications for Portland Cement Concrete.
2. Waterproof paper used for curing concrete shall conform to ASTM Designation C 171, "Specifications for Sheet Materials for curing concrete".
3. Liquid membrane compound used for curing concrete shall conform to ASTM Designation C 309, "Specifications for Liquid Membrane-Forming Compounds for Curing Concrete".
4. White polyethylene sheeting shall meet the requirements of AASHTO Designation M 171.

500.55 FORMS

1. The form material shall be able to conform to the shape, lines, and dimensions of the member as called for on the plans and further, shall be able to maintain this conformance after the placement has been completed until the concrete hardens sufficiently to permit the removal of these forms. All forms used for exposed surfaces shall be clean, smooth, free of loose knots, dents, wrinkles, bends, warpage, protruding surfaces (all rivet heads, bolt and screw heads on metal forms contacting the concrete surface shall be counter sunk) and all other imperfections which will mar the smoothness required and/or continuity of alignment of the exposed concrete surface(s).
2. Form Oil. Form oil will be used for the purpose of preventing the forms from adhering to the concrete and shall be an approved, clean, colorless, mineral oil which will not discolor or otherwise injure the concrete surfaces. Form oil shall be applied before reinforcing steel is placed.
3. Form Ties. Metal ties or anchorages within the forms shall be constructed to permit removal to a depth of not less than one-half inch (1/2") from the face of the concrete without injury to the concrete. All fittings for metal ties shall be designed so that when removed, the cavities resulting from such removal will be of small size.

SECTION 505

CONCRETE PLACEMENT AND FINISHING

505.00 GENERAL

Concrete curb and gutter, sidewalk, drivepads (driveways), and valley gutters shall conform to this and other applicable sections of these specifications, to details as shown on the drawings, and to City of Las Cruces Standards. Slip form pavers may be used as an alternative in place of fixed forms.

505.05 EXCAVATION AND SUBGRADE PREPARATION

This work will be performed in accordance with Section 200, EXCAVATION, SITE, AND SUBGRADE PREPARATION, of these specifications. The Inspector shall approve the subgrade before concrete is placed. The subgrade shall be moistened before placing concrete. When the subgrade has been over-excavated and forms are in place, deviation from compaction specifications by placing loose fill will not be allowed, and the Contractor shall either remove the forms for proper compaction or place concrete of additional thickness to compensate for the over-excavation.

505.10 JOINTS

1. General. Construction joints shall be located as shown on the plans and at other points as may be necessary during construction provided that the location and nature of additional joints shall be made as shown in the details on the plans. In resuming work abutting a construction joint, the surface of the concrete previously placed shall be thoroughly cleaned of dirt, scum, laitance, or other soft material and shall be roughened. The surface then shall be thoroughly washed with clean water. All contraction joints must be constructed at the time the concrete is poured and finished and shall be a minimum of 1/8 the depth of the concrete being weakened.
2. Concrete Curb and Gutter. Expansion joints shall be placed at not greater than fifty foot (50') intervals, at the tangent points of all curves, and as further shown on the plans. Expansion joints shall be one-half inch (1/2") thick, shall be formed to the surface shape of the curb and gutter, and shall extend to full depth. The top shall be even with the finished surface after the concrete has hardened.

Contraction joints (weakened plane joints) shall be placed at ten foot (10') centers and shall be formed with metal templates not more than one-eighth inch (1/8") thick.

3. Sidewalk. Expansion joints as described above shall be installed as described. Expansion joints shall be provided at twenty feet (20') on centers and where sidewalks abut existing walks, buildings, driveways, or other construction. Contraction joints (dummy joints) shall be provided at the same location as joints in curb and gutters and at (5') intervals (midpoints).
4. Drivepads and Valley Gutters. Drivepads and valley gutters shall have expansion and contraction joints as shown on the drawings. Drivepads from twelve (12) to thirty-five feet (35') long shall have one-half inch (1/2") preformed expansion joints at centerline. Construction methods shall be as described above

for curb and gutter. Valley gutter joints shall have the preformed expansion joint filler depressed one-half inch ($\frac{1}{2}$ ") and the top one-half inch ($\frac{1}{2}$ ") shall be filled with joint filler as specified. Contraction joint spacing will be the same as for sidewalks.

5. Handicap Access Ramps. Expansion and construction joints shall conform to Standard Detail B with $\frac{1}{2}$ " expansion joints at the top of the side slopes. Ramps must conform to the current ADA as defined by the Federal Registrar.

505.15 PLACING - FORMS

At such time when the forms have been completed and the reinforcing steel has been placed, and prior to the placing of concrete, an inspection will be made of the forms and reinforcing steel for conformity with the required lines, grades, dimension sizes, and contours as shown on the plans, and other such incidentals necessary to insure that the finished concrete member will be in accordance with the plans and specifications. No concrete will be placed until this inspection has been completed by the City of Las Cruces.

1. Form Construction. Forms shall be so designed and constructed that they shall:
 - A. Conform to the shape, line, and dimensions of the member(s) called for on the plans, and shall be sufficiently tight to prevent leakage of mortar.
 - B. Maintain the continuity of the shape, lines, and dimension of the member(s) for which they were constructed during and after the pour until they are stripped, without bulging, bending, warping, sagging, or in other ways changing the intended contours.
2. Form Details. No wood device of any kind used to separate forms shall be permitted to remain in the finished work. Temporary openings shall be placed at the bottom of column and wall forms and at other points where necessary to facilitate cleaning and inspection immediately before depositing concrete.

505.20 PLACING - REINFORCING STEEL

1. Reinforcing Steel Shipments. Bar reinforcement shall be shipped in standard bundles tagged and marked in accordance with the Code of Standard Practices of the Concrete Reinforcement Steel Institute.
2. Reinforcing Steel Bending. Bent bar reinforcement shall be cold shop bent to the shapes shown on the plans. Unless otherwise provided, bends shall have a radius of not less than three (3) bar diameters.
3. Clean Reinforcing Steel. Metal reinforcement, at the time concrete is placed, shall be free from loose rust, mud, oil, or other coatings that will destroy or reduce bond.
4. Tying and Spacing of Reinforcing Steel. Reinforcing bars shall be placed as shown on the plans and shall be securely tied in position with No. 14 or No. 16 gauge wire at all intersections, except where the spacing is less than one foot (1') in either direction, in which case alternate intersections shall be tied. Metal spacers, chairs, hangers, and other approved devices shall be used to hold the reinforcement in position. Bars shall be placed with a variation in spacing between adjacent bars of not to exceed one-quarter inch ($\frac{1}{4}$ ") or one-twenty-fourth ($\frac{1}{24}$) of the spacing dimension shown on the plans, whichever

is greater. The clear coverage of the reinforcement shall not vary more than one-eighth (1/8) of the dimension shown on the plans.

5. Splicing Reinforcing Steel. No splices of reinforcement shall be made except as shown on the plans or job approved shop drawings or as specified in the special provisions of the specifications or as authorized by the Engineer. Unless otherwise shown on the plans, job approved shop drawings, or specified in the special provisions of the specifications, bars in the bottom of beams and girders, and in walls, columns and haunches shall be lapped a minimum of twenty-four (24) diameters, and bars near the tops of beams and girders having more than twelve inches (12") of concrete under the bars shall be lapped a minimum of thirty-six (36) diameters to make the splice. No lap shall be less than twelve inches (12"). Mesh and bar mat reinforcement shall be lapped not less than one (1) mesh width, and tied where shown on plans.
6. Minimum Cover of Reinforcing Steel. The minimum cover from the surface of the concrete to the face of any reinforcement bar shall not be less than three inches (3"), unless otherwise shown on the plans.
7. Welding of Reinforcing Steel. Reinforcing steel shall be welded only when shown on the plans or authorized in writing by the Engineer. Welding, when done, shall conform to the current "Specifications for Welded Highway and Railway Bridges" of the American Welding Society.

505.25 PLACING CONCRETE

1. General. Before concrete is placed, all equipment for transporting and conveying the concrete shall be clean, and all debris, ice, and other deleterious materials shall be removed from the interior of the forms to be filled with the concrete. Forms shall be thoroughly wetted or oiled, masonry filler units that will be in contact with concrete shall be well drenched, and the reinforcement shall be thoroughly clean of ice, oil, or other deleterious coatings and shall be secured in position, then inspected by the City of Las Cruces.
2. Subgrade. Water shall be removed from the place of deposit before concrete is placed unless other provisions are made and approved by the Engineer. If concrete is to be placed upon a subgrade, the subgrade shall be thoroughly moistened at the time the concrete is deposited.
3. Conveyance. Concrete shall be conveyed from the mixer to the place of final deposit by methods which will prevent the separation or loss of materials. Concrete that has attained its initial set, or has contained its water content for more than one (1) hour and/or has been contaminated by foreign materials shall not be deposited in the work.
4. Equipment. Equipment for chuting, pumping, and pneumatically conveying concrete shall be of such size and design as to be mortar tight and to insure a practically continuous flow of concrete at the delivery point without separation of materials.
5. Continuity of Placement. When concreting is once started, it shall be carried on as a continuous operation until the placing of the panel or monolithic section is completed.

6. Placement.

- a. Concrete shall be deposited in horizontal layers and shall be thoroughly consolidated by suitable means during placement in such a manner that all voids will be filled and segregation will not occur and further that reinforcing steel and/or forms will not be displaced. Concrete in walls and other similar structure layers shall not exceed two (2) foot in depth and the capacity of the mechanical vibrator to consolidate the concrete and merge it with the previous lift. Segregation from excessive drop will not be allowed. Concrete shall not have a free fall of more than five (5) feet. In the case of walls ten (10) inches or less in thickness the concrete may have a free fall not to exceed nine (9) feet.
- b. Consolidation of concrete may be achieved by mechanical vibrators of an approved type and design and shall be capable of transmitting vibration to the concrete at frequencies of at least 5000 impulses per minute. Vibrators shall be used to manipulate the concrete thoroughly around the reinforcement, fixtures, corners, and angles within the forms. Vibrators shall be placed perpendicular to the form and shall not be used as a means to move concrete. The vibration duration shall be sufficient to consolidate the concrete but shall not be prolonged to the point that the concrete begins to segregate.

7. Cold Weather Concrete. Concrete shall not be placed when the atmospheric temperature is at or below 40° F., unless authorized by the Engineer in writing. If so authorized, the aggregates and water shall be heated as herein provided.

If concrete pouring is authorized for temperatures at or below 40° F, the Contractor shall furnish equipment capable of producing concrete that will have a temperature of not less than 50° F at the time of placement. If the concrete is obtained from ready-mix sources, it too shall have a temperature of not less than 50° F at the time of placement. Heating procedures for job-mix or ready-mix concrete that alter or prevent the entrainment of the required amount of air in the concrete will not be permitted. The equipment for job-mix or ready-mix concrete shall heat the materials uniformly and prevent damage to aggregates by over-heating. Aggregates and water used for mixing shall not be heated to a temperature exceeding 120°F. Materials containing frost or lumps of frozen material shall not be used.

After the concrete is placed, the air temperature surrounding such concrete shall be maintained at a temperature of not less than 45° F for a period of four (4) days. Following the four (4) day period, the concrete shall be protected from air temperatures below 35° F for an additional four (4) day period.

No chemical or other foreign matter shall be added to the concrete for the purpose of preventing freezing.

8. Hot Weather Concrete. During hot weather, proper attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperature or water evaporation that may impair required strength or serviceability of the concrete member or structure and every effort shall be made to maintain the concrete temperature of concrete produced to less than ninety degrees F (90° F).

9. Adverse Conditions. Material application shall cease if the wind velocity exceeds 25 MPH. The wind velocity shall be the velocity in miles per hour determined by the Projects Inspector by

averaging the maximum and minimum wind velocity observed in any three (3) minute period prior to or concurrent to ongoing operations. The wind velocity shall be measured three feet above the roadway surface.

505.30 SAMPLES AND TESTING

1. ASTM STANDARDS. The following current ASTM Standards shall apply for each test:
 - A. Sampling. As the work progresses, concrete shall be sampled in accordance with "Method of Sampling Fresh Concrete," ASTM Designation C 172.
 - B. Slump Tests. Slump tests shall be made according to "Method of Test for Slump of Portland Cement Concrete," ASTM Designation C 143.
 - C. Air Content. Air content shall be tested in accordance with "Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method," ASTM Designation C 231.
 - D. Compression Test Specimens. Compression test specimens shall be made and cured according to "Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field," ASTM Designation C 31.
 - E. Compression Tests. Specimens shall be tested according to "Method of Test for Compressive Strength of Molded Concrete Cylinders," ASTM Designation C 39. The standard age of test specimens shall be twenty-eight (28) days, but seven (7) day specimens may be used, provided that the relationship between seven (7) and twenty-eight (28) day strengths of the concrete is established by test for the materials and proportions used.
 - F. Concrete Temperature. Shall be measured in the field in accordance with ASTM C-1064 and other approved methods.
2. TESTING.
 - A. The Contractor shall furnish whatever labor, assistance, and cooperation is necessary to facilitate proper concrete sampling as may be conducted.
 - B. Testing for compliance before and during the progress of the work will be performed by an approved independent testing laboratory. **The City will have tests done on the material as listed below at the project site(s), if the contractor chooses to modify the material in the truck by adding water or any other means, they must do so at their own risk and prior to the sampling and testing by the City. If any modifications are made to the materials after the tests have been conducted, the City will require the material to be retested at the contractor's expense.** A test shall be considered as the average strength of two (2) cylinders at twenty-eight (28) days.
 - C. Failure to meet specified limits shall constitute questionable concrete, and additional tests from hardened concrete in accordance with ASTM C 42 shall be performed at the Contractor's expense, if required. In the event that the concrete placed does not conform to these specifications, measures

as prescribed by the Engineer shall be taken to correct the deficiency at no additional expense to the City.

- D. The minimum number of tests taken for each class of concrete shall be at least one (1) test taken for each fifty (50) yards of concrete or fraction placed with no less than one (1) test taken for each day's placement.
- E. Additional specimens cured under job conditions may be required when, in the opinion of the Engineer, there is a possibility of the surrounding air temperature falling below 40° F, or rising above 90° F.
- F. Tests shall be distributed throughout the work so as to be representative of all the work.

505.35 FINISHING

- 1. Concrete Curb and Gutter. The Contractor shall use metal screeds or mules designed to properly shape the curb and gutter to the dimensions and sections shown on the plans. Final finish shall be obtained by fine-brushing to an approved finish.
- 2. Sidewalk, Drivepads, and Valley Gutters. Finish for sidewalk, drivepads, and valley gutters shall be performed as described for finishing of slabs in Section 500, PORTLAND CEMENT CONCRETE AND CONCRETE RELATED MATERIALS. The sequence shall be strike-off and consolidation, floating and removal of laitance, straightedging, steel troweling, and final surface finish by brooming to an approved finish.
- 3. Unless otherwise specified on the plans or specifications, immediately after removal of the forms, all fine and loose material shall be removed. Aggregate pockets, voids, honeycomb, and holes shall be cut to solid concrete, thoroughly wetted, and filled with cement thirty percent (30%) of which is white cement, to three (3) parts of fine aggregate. To prevent scaling, no operation shall be performed on any surface while bleed water is present. Final degree of finish shall be as follows: After screeding, straightedging, and finishing with a steel trowel, a final finish shall be obtained by fine-brushing to an approved finish.

505.40 TOLERANCES

- 1. Concrete Curb and Gutter. On straight sections, the top surface of the forms shall not vary more than one-quarter inch (1/4") in ten feet (10') from the established grade and the inside face of the forms shall not vary more than one-quarter inch (1/4") in ten feet (10') from the established alignment. On curved sections, the top surface of the forms shall not vary more than one-quarter inch (1/4") from a true arc. The use of straight sections of forms acting as chords on curved sections will not be permitted. Sidewalks shall have a transverse slope of one-quarter inch (1/4") per foot.
- 2. Sidewalk, Drivepads, and Valley Gutters. Final finish for sidewalk, drivepads, and valley gutters shall be such that there will be no surface deviations in excess of one-quarter inch (1/4") when tested with a ten foot (10') straightedge.

505.45 CURING

1. General. Water curing or curing with moist-earth cover will not be allowed due to difficulty in maintaining this type of curing. Concrete pavement, floors, slabs, and top of bottom slabs of concrete box culverts, sidewalks, footpaths, curb and gutter, drivepads, valley gutters, and other horizontal or sloped surfaces shall be cured by one of the following methods:
 - A. Spraying method.
 - B. Sheet Plastic Method.
 - C. Impervious Membrane * (curing compound).

* On surfaces that are the face of a construction joint, the membrane method shall not be used

All exposed surfaces of formed concrete members, unless otherwise provided, and unless the forms are left in place and cover the surface, shall be cured for not less than seven (7) days where ordinary Portland cement is used, or for three (3) days where high-early strength Portland cement is used.

2. Methods.

- A. Spraying. Curing compound shall conform to ASTM Designation C 309, "Specifications for Liquid Membrane-Forming Compounds for Curing Concrete," and shall be applied after the surface water has disappeared from the concrete surfaces.
- B. Sheet Plastic Method. After the final finishing operation, and the concrete has set up sufficiently to prevent marring the surface, the top of the slab and sides (if exposed) shall be entirely covered with waterproof paper or polyethylene sheets conforming to previously stated material specifications. The units as used shall be lapped at least eighteen inches (18"), the material used shall so be placed and weighted as to cause it to remain in intimate contact with the surface covered. The material used shall remain in place at least seven (7) days, unless otherwise provided. The material shall be of such dimensions that it will extend beyond the edges of the slab at least twice the thickness of the slab. All overlapping sections must be secured by suitable means such that they do not open up or separate during the curing period.
- C. Impervious Membrane. Clear or translucent impervious membrane curing compound shall be used for all concrete surfaces when this method is used except that the white pigmented type shall be used for concrete riding pavement surfaces. All surfaces shall be given the required surface finish prior to application of impervious membrane curing compound. The impervious membrane curing compound shall conform to previously stated materials specifications. During the finishing period, the concrete shall be protected.

The minimum rate of application shall be one (1) gallon of liquid for three hundred (300) square feet or as recommended by the manufacturer. All concrete cured by liquid curing compound shall receive two (2) applications of such compound. The first coat shall be applied immediately after stripping forms and acceptance of the concrete finish. When the surface is dry, the concrete shall be thoroughly wet with water and the curing compound shall be applied immediately after the surface film of the water disappears. The second application shall be applied immediately after the first application has set. During curing operations, any unsprayed surfaces shall be kept wet with water.

The coating shall be protected against marring or traffic for a period of not less than seven (7) days after application. Any coating that is marred or otherwise disturbed shall be given an additional coating. When using impervious curing compound, the material shall be thoroughly mixed by the use of air, within one (1) hour before use, to recombine any materials that may have become separated. When the use of impervious curing compound results in a streaked or blotchy appearance, the application shall be discontinued and water curing shall be applied until the cause of the defect in appearance has been corrected.

- D. Leaving Forms in Place. Curing of formed surfaces may be accomplished by leaving the forms in contact with the concrete surfaces for a period of seven (7) days. The forms will be required to be kept continuously moist during periods of hot, dry, or windy weather.
- E. Alternate Methods. Upon written approval of the Engineer, the Contractor may use methods other than those mentioned herein for curing concrete, provided that such method will prevent moisture loss from the concrete for a period of no less than seven (7) days, unless otherwise provided.

505.50 REMOVAL OF FORMS

- 1. LOAD-BEARING FORMS - and shoring shall not be removed until the seven (7) day test cylinders (or if directed by the project manager, the three [3] day test cylinders) have an average compressive strength of at least 66% of the required strength).
- 2. NON-BEARING FORMS - shall remain in place until concrete has had sufficient time to set up and will not slump or deform upon removal of the form.

505.55 BACKFILLING AGAINST CONCRETE

- 1. LOAD-BEARING STRUCTURE - backfill material shall not be placed against the concrete until the seven (7) day test cylinders (or if directed by the project manager, the three [3] day test cylinders) have an average compressive strength of at least 66% of the required strength).
- 2. NON-BEARING STRUCTURES - backfill material shall not be placed against the concrete until there has been time for an adequate average strength to support the load imposed on the concrete.

505.60 PATCHING AND REGRADING

- 1. PATCHING - The contractor shall be required to patch asphalt pavement adjacent to constructed or reconstructed curb and gutter. This work shall be incidental to the unit price for curb and gutter work in those areas unless otherwise specified.
- 2. REGRADING - The contractor will be required to maintain a neat work area and replace adjacent surfaces to match the new construction with materials similar to conditions prior to construction.

505.65 CLEANING

The contractor will not be permitted to leave piles of debris emanating from his work in the roadway areas over night. Each site must be cleared on a daily basis. If any material is piled in the roadway areas during construction, the contractor shall provide adequate barricading to ensure the safe passage of traffic around the work area.

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SECTION 510

MANHOLE AND VALVE BOX REGRADING

510.00 GENERAL

This section shall be used for the regrading of Utility access covers when required. Refer to Exhibit E, in the Standard Details for dimensions and additional specifications.

510.10 MATERIALS

Concrete materials shall conform to section 500, PORTLAND CEMENT CONCRETE AND CONCRETE RELATED MATERIALS.

510.20 RE-USE OF MANHOLE RINGS AND COVERS AND VALVE BOXES

The Contractor shall clean and re-use the existing manhole rings and covers and valve box frames, pipes, and covers. Manhole rings and covers and valve box frames, pipes, and covers damaged during raising and lowering or during construction shall be replaced by the Contractor at the Contractor's expense.

510.30 MANHOLE REGRADING (3000 psi concrete)

The ring and cover shall be brought level flush with the finished surface of the pavement by adjusting either up or down. Brick for manhole work shall conform to ASTM Designation C 32, Sewer Brick (Made from Clay or Shale), Grade SA. Mortar shall be one part of cement to two (2) parts of fine sand with lime allowed as an additional ingredient up to twenty-five percent (25%) of the volume of the cement.

1. Raising of Sewer Manholes. If ring and cover is not to be raised enough so that one (1) brick course can be used, then grout with a twenty-eight (28) day compressive strength of three thousand (3,000) psi, or concrete with a small size aggregate and the same compressive strength, shall be used. A maximum of three (3) brick courses will be allowed under the manhole frame in any manhole. If more than three (3) brick courses are required to adjust the frame to finished grade, the cone shall be removed, the necessary adjustment made in the barrel, and the manhole cone rebuilt. A one-half inch (1/2") Portland cement mortar (plaster) surface shall be applied on the inside and outside of the rebuilt surfaces, and shall be applied to existing adjacent surfaces where damaged.

After the brick coursing, grout, or concrete leveling is performed or the cone removed and rebuilt as herein described, and the manhole frame is to an elevation to match the finished surface, a concrete collar with vertical sides to the cone as shown on the drawings shall be provided around the outside of the frame. In unpaved areas, the mortar surface shall extend to the top of the manhole frame, covering both brick and side of frame.

2. Lowering of Sewer Manholes. If a sewer manhole is to be lowered, other than a slight adjustment, the cone shall be removed, the adjustment taken up in the barrel, and the cone reset. A one-half inch (1/2") Portland cement mortar (plaster) surface shall be applied on the inside and outside of the rebuilt surfaces and shall be applied to existing adjacent surfaces where damaged.

3. Backfill. All backfill shall meet the requirements of Section 200, EXCAVATION, SITE AND SUBGRADE PREPARATION. The backfill material must be compacted to 95% of the modified proctor.

510.40 VALVE BOX REGRADING (3,000 psi concrete)

Valve boxes shall be adjusted to the level of the finished street. Installation shall conform to the details as shown on the drawings.

510.50 TOLERANCE

The finished grade of all Utility access covers shall not deviate more than 1/4 inch from the adjacent surface over a ten foot straight edge or string line laid in the direction of traffic.

The contractor will be required to tamp the asphalt pavement adjacent to the covers before the concrete is poured and set to grade.

510.50 ACCESSIBILITY TO VALVES

The Contractor shall maintain accessibility to all valves at all times during construction.

SECTION 515 FLOWABLE FILL

515.00 GENERAL

This material may be specified for placement as backfill in narrow trenches when it is not feasible to place and compact adequate base course materials conforming to the adjacent section. The flowable fill shall consist of portland cement, aggregates, and water complying with these specifications.

515.10 AGGREGATE

Aggregates shall comply with the requirements of ASTM C 33 and shall be combined to provide a mixture of coarse and fine aggregate having a sand to total aggregate ratio of not less than seventy-five percent (75%) and not greater than eighty percent (80%) by weight. Unless approved by the Engineer the combined aggregate gradation shall comply with the following limits:

SCREEN SIZE	% PASSING
1 inch	100
3/4 inch	95 - 100
3/8 inch	82 - 94
No. 4	70 - 85
No. 8	55 - 75
No. 16	38 - 64
No. 50	6 - 22
No. 100	2 - 8

515.20 WATER

Water shall be proportioned as required and shall conform to the requirements of ASTM C 94.

515.30 CEMENT

Cement used in flowable fill shall be portland cement conforming to the requirements of ASTM C 150 and shall be Type I or Type II, "low alkali" cement.

The cement shall be sampled and tested in accordance with ASTM C 150 and the Contractor shall provide certification of compliance signed by the cement manufacturer identifying the cement and stating that the cement delivered to the batching site complies with the ASTM specifications. When requested by the Engineer, the Contractor shall furnish three (3) copies of said certification.

515.40 PLACEMENT

1. Flowable fill shall not be placed until a design mix has been submitted and approved by the Engineer.
2. Flowable fill shall be placed in lifts not exceeding four feet (4') in height, at time intervals of not less than one hour per lift. Fill shall not be placed to a height above top of pipe exceeding two feet (2') when used to fill a pipe zone, nor placed full depth in a trench to finish subgrade elevation unless approved by the Engineer.
3. Flowable fill shall not be placed in standing water and shall be protected from flooding for at least twelve (12) hours after placement.
4. Flowable fill shall not be placed on frozen or saturated ground.
5. Flowable fill shall be vibrated after placement as required by the Engineer.

515.50 MIX DESIGN

The Design Mix shall be proportioned to provide a slump of not less than five inches (5") and not greater than eight inches (8"). The strength of the combined mixture must be greater than 100 psi and less than 150 psi at 28 days.

SECTION 520

PIPE CULVERTS AND STORM DRAIN PIPE

520.00 GENERAL

This work shall consist of furnishing, construction, and reconstruction of pipe culverts and storm drains in compliance with specifications and to the lines and grades shown on the approved plans.

520.10 MATERIALS

The type selected shall be furnished on a given project throughout the applicable range of sizes, wall thickness, classes, and dimensions shown on the plans.

- A. STEEL CULVERT PIPE: All pipe shall conform to the requirements of AASHTO M36.
- B. ALUMINUM CULVERT PIPE: All pipe shall conform to the requirements of AASHTO M196.
- C. REINFORCED CONCRETE PIPE: All pipe shall conform to the requirements of AASHTO M170 for round pipe, AASHTO M206 for arch pipe, and AASHTO M207 for elliptical pipe.
- D. CORRUGATED POLYETHYLENE PIPE: All pipe, couplings, and fittings shall conform to the requirements of AASHTO M252 and ASHTO M294.
- E. POLYVINYL CHLORIDE PIPE: All pipe and joint connections shall conform to the requirements of AASHTO M304.

520.20 PIPE IDENTIFICATION REQUIREMENTS

All sections of pipe shall be clearly marked with class of pipe, date of manufacture, and name or trademark of manufacturer.

520.30 CONSTRUCTION

Trenches shall be excavated in accordance with the requirements of Section 205, Trench Excavation and Backfill.

520.40 PIPE BEDDING

The pipe shall be bedded in a foundation of stable earth material compacted to the requirements of Section 200.01 (G) and accurately shaped by means of a template to fit the lower part of the pipe exterior for at least 15% of its overall height.

520.50 LAYING PIPE

Pipe laying shall begin at the downstream end of the pipe, except for extensions of existing pipe. The bottom of the pipe shall be in contact with the shaped bedding throughout its full length. The female ends, or outside circumferential laps of pipe shall be placed facing upstream. Pipe with longitudinal laps or seams shall be placed with laps or seams at the sides.

520.60 INSPECTION

Prior to backfilling, pipe shall be inspected before any backfill is placed. Pipe found to be out of alignment, unduly settled, or damaged shall be taken out and relayed or replaced at no additional cost to the City.

520.70 BACKFILL

Backfilling shall be in accordance with the requirements of Section 205, Trench Excavation and Backfill.

SECTION 525 MORTAR

525.00 GENERAL

This material may be specified for placement in rock wall structures or concrete structures when filling voids or repairing surface defects. The mortar shall consist of portland cement, aggregates, and water complying with these specifications.

525.10 MATERIALS

The mortar shall be a sand/cement mixture containing: Portland Cement, sand, water, and other approved additives. No chlorides, fluorides, sulfites, nitrates or gas forming agents will be permitted.

The twenty eight (28) day compressive strength of mortar cubes shall be at least 1200 psi for rock walls and 3000 psi for concrete structures unless otherwise noted on plans. Mortar cubes will be sampled cured and tested in accordance with AASHTO T 106 and Section 505.30.

525.20 AGGREGATES

Aggregates shall be free of deleterious materials in an amount not to exceed 3.0% by weight. Fine Aggregates shall comply with the requirements of ASTM C 33 and shall be well graded from coarse to fine in accordance with the following table:

SCREEN SIZE	% PASSING
3/4 inch	100
No. 4	95 - 100
No. 16	45 - 80
No. 50	5 - 30
No. 100	0 - 10
No. 200	0 - 03

525.30 WATER

Water shall be proportioned as required and shall conform to the requirements of ASTM C 94.

525.40 CEMENT

Cement used in mortar fill shall be portland cement conforming to the requirements of ASTM C 150 and shall be Type I or Type II, "low alkali" cement.

The cement shall be sampled and tested in accordance with ASTM C 150 and the Contractor shall provide certification of compliance signed by the cement manufacturer identifying the cement and stating that the

cement delivered to the batching site complies with the ASTM specifications. When requested by the Engineer, the Contractor shall furnish three (3) copies of said certification.

525.50 PLACEMENT

Mixing shall be done by either hand methods or with rotating paddle type mixing machines and shall be continued until all ingredients are thoroughly mixed. Only enough water shall be used to permit placing and packing. Once, mixed mortar shall not be retempered by the addition of water and shall be placed within one (1) hour.

Cement that is stockpiled before mixing occurs shall be kept free from contact with soil and shall not be exposed to weathering for a period longer than 24 hours. Concrete or rock surfaces to be in contact with the mortar shall be cleaned of all loose or foreign material that would in any way prevent a bond between the mortar and the base surface. The mortar shall completely fill and be tightly packed into recesses and holes. The contractor shall screed the material to the required level and finish the surface to the texture specified.

No load shall be allowed on mortar that has been in place less than seventy two (72) hrs., unless otherwise permitted by the Project Manager.

525.60 MIX DESIGN

Unless otherwise specified by the project manager or plans, the proportion of cement to sand shall be one (1) to three (3) for rock walls and one (1) to two (2) for concrete structures. The strength of the combined mixture must exceed 1200 psi at 28 days for rock walls and 3000 psi at 28 days for concrete structures.

SECTION 600

PAVEMENT MARKINGS

600.10 DESCRIPTION

This work shall consist of furnishing and placing pavement markings, reflectorized plastic pavement symbols, legends, and stripes in accordance with the specifications, the MUTCD, and as shown in the contract.

600.20 TRAFFIC PAINT

Traffic paint shall conform to the requirements of the NMSHT Department's Specifications for White and Yellow Traffic Line Paints Used on Construction Projects (Combination Alkyd and Hypalon--Fast Dry Type) Specification M-TPC-90H2. Traffic paint shall be free of lead, mercury, cadmium, hexavalent chromium, and any other toxic heavy metals.

The Contractor shall provide certificates of compliance and documentation that the batch of paint to be used has been tested by the NMSHT Department's Central Materials Laboratory. Documentation from the Central Materials Laboratory will indicate whether the paint meets or does not meet specifications.

If the Contractor elects to use the traffic paint prior to submitting the proper documentation, the applied striping will be subject to rejection.

If the tests results for that batch of paint do not meet specifications, the paint will be subject to price reduction as set forth in the specifications for traffic paint, "M-TPC-90H2, Price Adjustment Schedule for White and Yellow Traffic Paints Used on Construction Projects Prior to Obtaining Written Approval" or, as determined by the Project Manager, the Contractor shall remove the striping, and restripe the roadway, at no additional cost to the Department.

600.30 GLASS REFLECTORIZED BEADS

Glass reflectorized beads shall conform to the requirements of the NMSHT Department's Specifications for Glass Beads, Designation MGRB, Type DAB.

600.40 TEMPORARY MARKING TAPE

Temporary marking tape shall consist of traffic resistant yellow or white reflective marking material on a conformable non-metallic or metallic backing coated with a pressure sensitive adhesive and designed for marking of bituminous or portland cement concrete surfaces. The material shall be weather resistant and show no appreciable fading, lifting, or shrinkage. The materials as supplied shall be of good appearance and free from cracks, and the edges shall be true, straight, and unbroken.

A. Color. The color of the visible or outer surface, when compared visually, shall closely match the color of the paint specified in Subsection 600.20 Traffic Paint. Wear resistance samples of temporary marking tape applied to standard specimen plates and tested in accordance with Federal Test Methods No. 141,

Method 6192, using CS-17 wheel and 1000 gram load shall not exhibit a significant change in color after 5000 cycles.

- B. Retroreflectivity. The white and yellow temporary marking tape shall meet or exceed the minimum retroreflectivity values outlined in ASTM D-36.
- C. Adhesion. The material shall have a precoated pressure sensitive adhesive which does not require a liner for protection from contamination, pre-adhesion, or blocking within the roll. The material shall show no appreciable loss of adhesion after application.
- D. Conformability. The material shall be flexible and formable, shall show no cracking, flaking, or loss of reflective elements and, following application, shall remain conformed to the texture of the pavement surface.
- E. Packaging, Storage, & Shelf Life Requirements. The removable marking tape shall be packaged in accordance with accepted commercial standards, shall be stored at temperatures not to exceed 100 degrees Fahrenheit under normal conditions, and shall be suitable for use for a period of at least one (1) year after purchase.
- F. Dimensions.
 - 1. Removable Temporary Marking Tape for normal use, shall be at least thirty five (35) mils in thickness and shall be provided in four (4) inch or (6) inch width (+-1/16 inch). Removable marking tape shall be readily removable from the pavement by following the manufacture's recommendations, unless otherwise specified. Removal shall not require sandblasting, solvent, burning, or grinding methods and shall not result in objectionable staining of the pavement surface.
 - 2. Non-Removable Temporary Marking Tape Dimensions for normal use, shall be at least ten (10) mils in thickness and shall be provided in four (4) inch or (6) inch width (+-1/16 inch).

600.50 PLASTIC MARKINGS

Retroreflectivity preformed plastic marking material shall consist of white or yellow weather resistant film as specified herein. Markings shall be new or shall have been stored in a cool, dry area, indoors at normal shelf temperature and shall have been purchased within one (1) year of the intended date of placement. Prefabricated legends and symbols shall conform to applicable shapes and sizes as outlined in the MUTCD for Streets and Highways.

- A. Composition. Retroreflective preformed plastic markings shall consist of high quality plastic materials, pigments, and glass beads uniformly distributed throughout their cross sectional area, with a reflective layer of beads embedded in the top surface. Material shall be furnished with the appropriate adhesive system recommended by the manufacturer for successful installation.
- B. Skid Resistance. The surface of the retroreflective preformed plastic marking material shall provide a minimum skid resistance value of thirty five (35) British Pendulum Number (BPN) when tested according to ASTM E 303.

C. Thickness. The thickness of the retroreflective preformed plastic marking material includes symbols and legends without adhesive shall be sixty (60) mils when inlaid into new bituminous surfaces and ninety (90) mils when applied onto existing surfaces.

D. Durability & Wear Resistance. The retroreflective preformed plastic marking materials, when properly applied, shall provide a neat, durable marking. The preformed plastic material shall provide a cushioned resilient substrate that reduces bead crushing and loss.

The film shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting, or shrinkage throughout the life of the marking, and shall show no significant tearing, rollback or other signs of poor adhesion. Applied in accordance with the manufacturer's recommendations, retroreflective plastic pavement markings shall have an effective performance life of at least three (3) years.

E. Conformability & Resealing. The retroreflective, preformed plastic marking material shall be capable of conforming to pavements contours, breaks, faults, etc., through the action of traffic at normal pavement temperatures. The film shall have resealing characteristics such that is capable of fusing with itself and previously applied marking film of the same composition under normal conditions of use.

F. Tensile Strength. Retroreflectivity pliant polymer marking material shall have a minimum tensile strength of forty (40) psi of cross section when tested according to ASTM D 638 using a jaw speed of 0.25 inch per minute. In addition, retroreflective pliant polymer pavement marking material shall support a dead weight of four (4) pounds for at least five (5) minutes. Test specimen size shall be six (6) inches by one (1) inch by 0.06 inch minimum thickness.

G. Elongation. Retroreflective paint polymer pavement material shall have a minimum elongation of fifty percent (50%) when tested in accordance with ASTM D 638.

H. Pigmentation. The pigment for retroreflective preformed plastic marking material shall be selected and blended to provide a plastic which is white or yellow conforming to standard highway colors through the expected life of the pavement marking plastic.

I. Glass Beads for Retroreflective Preformed Plastic Markings. The glass beads for retroreflective pliant polymer pavement marking shall be colorless and shall have a minimum index of refraction on 1.50 when tested using the liquid oil immersion method. The size and quality of the beads will be such that performance requirements shall be met.

The pavement marking plastic shall have retention qualities such that when a two (2) inch by six (6) inch specimen is bent over a ½ inch diameter mandrel with the two (2) inch dimension perpendicular to the mandrels axis, a microscope examination of the area on the mandrel shall show no more than ten percent (10%) of the beads with entrapment by the binder of less than forty percent (40%).

600.60 CONSTRUCTION METHODS

The Contractor shall ensure that all paint sampling and handling procedures are performed in accordance with the requirements described herein.

- A. Redispersement of Settled Paint. When paint has settled excessively, the Contractor shall redisperse the settled pigments at the bottom of the paint drums, with a mixing device, prior to pumping or loading paint into the striping unit so that excess pigments are not left on the bottom of the paint drum. Thinner shall not be allowed to be pumped into the paint tanks.
- B. Drum Seals. Drums of paint used on construction projects shall be sealed at the point of manufacture and consecutively numbered with tamper-proof seals. These seals may only be removed with a City representative present for either testing purposes or at the time of actual use. Drums with broken seals, not opened by a City representative, will not be accepted.
- C. Equipment. The traffic paint, and beads shall be placed on the pavement by a spray type, self propelled pavement marking machine, except that temporary striping during construction may be placed with other equipment designed for application of paint, or beads.

The machine shall be capable of applying clear-cut four (4) inch lines, shall be equipped with a mechanical device capable of placing a broken reflectorized centerline with a ten (10) foot painted segment and a thirty (30) foot gap, and shall be equipped with an air-operated glass bead drop-in dispenser controlled by the spray gun mechanism.

The dispenser shall be capable of placing the glass spheres into the paint line as the paint is applied to the pavement in such a manner as to provide satisfactory marking and delineation..

- D. Measurement Devices. A method of measuring the actual volume of paint and beads in the tanks shall be provided on the tanks either by strap measurement or the Contractor may externally mark the tanks indicating a volume equivalent to the tolerances shown in Subsection F Volume Control Requirements, or have a calibrated rod marked with the equivalent volumes. The Contractor shall provide certification of the volume of the paint and bead tanks.
- E. Volume Control Requirements. The volume of paint and glass beads in place shall be measured by the quantity per mile method or by the use of paint and bead gauges. The Contractor shall strap the tanks prior to beginning striping operations and again after five hundred feet have been striped. At the option of the Project Manager, if the striping machine is equipped with air atomized spray units, (not airless), and paint and bead gauges, the volume may be determined by utilizing said gauges. The volumes shall be measured again, at the beginning and end of each day.
- F. Letter of Transfer for Paint. The paint and bead tanks of the Contractor's striper must be empty prior to filling for the beginning of the striping operations for the project unless a "Letter of transfer for paint" has been obtained. Paint or glass beads left over in the striping truck tank can be transferred from another City Project by providing a "Letter of Transfer for Paint," which shall include the following information:
1. The amount left in the tanks;
 2. The project it is coming from, including, the termini, the project number and control number;
 3. The project it is going to;
 4. The date;
 5. The batch number the paint came from;
 6. The seal numbers of the paint in the tank; and
 7. The previous Project Manager's signature.

600.70 PLACEMENT OF GLASS BEADS AND TRAFFIC PAINT

- A. Weather Limitations. Pavement markings shall be applied during daylight hours when the pavement surface is dry and the weather is not foggy, rainy, wind gusts in excess of 25 mph, or otherwise adverse to the application of markings.
- B. Surface Preparation. The surface shall be free from excess asphalt or other deleterious substances before traffic paint or beads are applied. The Contractor shall remove dirt, debris, grease, motor oils, rocks, or chips from the pavement surface before applying markings.
- C. Traffic Control Requirements. The Contractor shall provide the necessary personnel and equipment to divert traffic from the installation area where the work is in progress and during drying time. The Contractor shall submit a traffic control plan to the Project Manager for approval prior to the commencement of work, unless one has already been established in the contract. When applied to pavements with temperatures above 50 degrees Fahrenheit the paint shall be allowed to dry to a no-track condition of at least 3 minutes.
- D. Number of Striping Applications. Permanent reflectorized painted markings shall consists of two (2) applications of markings, unless otherwise designated in the contract. The first application shall be placed no sooner than fourteen (14) days after the placement of a new surface and the second application of markings shall be placed no sooner than fourteen (14) days after placement of the first application of markings, as directed by the Project Manager.
- E. Repair & Replacement of Unacceptable or Damaged Striping. If paint is not adhering to the pavement or if the glass beads are not adhering to the paint, or if the second application of pavement markings are not placed over the first application of markings in accordance with Subsection 600.35 Tolerance for Placing Paint & Beads., the Contractor shall remove the striping, and shall restripe the roadway. All damage to pavement markings due to the Contractor's negligence or failure to maintain traffic control shall be repaired at no additional cost to the Department.
- F. Tolerance Requirements for Placing Paint & Beads. The finished line(s) shall be smooth, aesthetically acceptable and free from undue waviness.
- H. Dimensions. Painted lines shall be the width shown in the plans with a tolerance of plus or minus 1/4 inch. The length of painted segment and gap shall not vary more than six (6) inches in a forty (40) foot cycle. The following transverse gap dimension between centerline stripes for two (2) and three (3) stripe combinations reflect a three (3) paint gun set up on the striping unit. The broken line shall be placed on the centerline of the roadway with the respective left and right no passing zones placed so that a two (2) inch gap exists between the broken and no passing zone stripe. There shall be an eight (8) inch gap between the double yellow markings for no passing zones.
- I. Application Rate.
1. Paint shall be placed at a minimum rate of 19.75 gallons of paint per mile for a solid four (4) inch line and 4.94 gallons pr mile for a broken four (4) inch line, based on a ten (10) foot stripe and a thirty (30) foot gap (forty (40) foot cycle). Other widths of striping shall be applied at the minimum rate that is the equivalent multiple of the above.

correct = 18 mils

Do 5 mils
per Dept
Specs no
10/1/17

2. Glass reflectorizing beads shall be applied on the wet paint at a minimum rate of six (6) pounds to each gallon of paint. This translates into a minimum weight of beads of 29.6 lbs. per mile of broken line and 118.5 lbs. per mile of solid line.

J. Temporary Marking Tape.

1. Contractor shall provide the necessary personnel and equipment to warn and divert traffic during installation and removal from the area where the work is in progress. The surface to which the tape is applied shall be dry and free of oils, grease, dust, dirt, and other deleterious substances and shall be primed with a primer material as recommended by the manufacturer of the tape. The tape shall be rolled or tamped down immediately after application until it adheres properly and conforms to the surface of the pavement. Where striping is continuous, there shall be no more than three (3) splices per 120 feet of length.

Only "removable marking tape" will be allowed for temporary marking of final pavement surfaces unless otherwise designated in the contract.

2. All temporary pavement markings placed on the final pavement surface shall be removed by the Contractor when such temporary pavement markings are no longer required for traffic control, as determined by the Project Manager. Removal of temporary marking tape shall be complete with no segments or pieces of tape remaining on the pavement. The use of non-reflective black removal marking tape and over painting, to obliterate temporary pavement markings will not be permitted.

600.80 PAVEMENT SYMBOLS, LEGENDS, STRIPES, AND MARKINGS

Retroreflective pliant polymer reflectorized plastic pavement symbols, legends, stripes and markings shall be applied to the pavement at the locations shown in the contract or as designated by the Project Manager. Retroreflective performed plastic pavement markings shall be applied to the roadway surface before final rolling is completed on new bituminous pavement. The pavement surface shall be clean and free of moisture, soil or other deleterious substances. A brooming or compressed air method shall be utilized to clean the pavement surface.

600.90 DISPOSAL OF HAZARDOUS MATERIALS

The Contractor shall dispose of thinner, solvent and all other hazardous waste in accordance with appropriate hazardous materials regulations.

SECTION 605

GENERAL REQUIREMENTS FOR LIGHTING SYSTEMS

605.10 DESCRIPTION

This work shall consist of furnishing and installing complete and functioning traffic signal and street lighting systems in accordance with the specifications, the latest editions or revisions of the MUTCD, NEMA Standards, AASHTO Standards and the NEC, and at the locations shown in the contract.

These specifications include general requirements that are applicable to all types of traffic signal and street lighting systems.

605.20 SIGNAL AND LIGHTING

Electrical materials shall conform to NEMA Standards and NEC requirements and to applicable state or local ordinances or requirements. In the event revisions to NEMA or NEC requirements create a conflict with material requirements, the more stringent shall apply.

The contract will indicate the extent and general arrangement of signal and lighting systems. Incidental parts not detailed, which are necessary to complete new systems or modify existing systems, shall be furnished and installed as though such parts are called for in the contract.

605.30 CONSTRUCTION METHODS

A. General. Electrical work shall conform to NEC requirements and to applicable local ordinances. The Contractor shall obtain a permit from the State Electrical Board (or equivalent state or local agency) prior to constructing the traffic signal or highway lighting systems or other electrical installations required by the contract and shall provide proof to the Project Manager before work begins. Only licensed electricians shall be employed to performed electrical work and install electrical materials required by the contract. In addition, the Contractor shall obtain approval from the electric utility for the exact location of the electric service before its installation.

Prior to final inspection of the project, the Contractor shall submit evidence to the Project Manager that all electrical work and installations have been inspected and approved by an authorized representative of the State Electrical Board. All systems shall be complete and in operation to the satisfaction of the Project Manager at the time the work is accepted.

B. Excavation & Backfill. Excavation required for the installation of conduit, foundations, and other items shall be conducted in accordance with Section 205 "Trench Excavation and Backfill" and shall be performed in a manner such that damage to streets and adjacent property is minimized. Excavation shall not be performed until immediately before installation of conduit and foundations. There shall be no cutting of existing pavement unless first approved by the Project Manager. For excavations in grassed or landscaped areas, the Contractor shall carefully remove existing landscaping prior to excavation and replace it after backfilling. The contractor shall plan the trenching and conduit placement operation to minimize the open trench and exposed conduit left overnight.

- C. Concrete & Reinforcing Steel. Concrete shall be Class A and shall conform with the requirements of Section 500 Portland Cement Concrete. Cement, air entrainment and other admixtures, water, and aggregate shall conform with the requirements of Section 500 Portland Cement Concrete. Steel reinforcement shall conform with the requirements of Section 500.35 Steel Reinforcement.
- D. Existing System Coordination. Existing signal and lighting systems shall be kept in operation until new material is installed and ready for operation, unless otherwise permitted in the contract. In this event, the Contractor shall not proceed with any work which will cause the existing signals to become inoperative until the Contractor has all materials for the new installation on hand, and the specified regulatory signing or temporary signals are in place and approved by the Project Manager.

The scheduling of shutdowns shall be in accordance with the construction traffic control plan. The Contractor shall notify the Project Manager and the maintaining agency in writing at least two (2) working days in advance of a scheduled shutdown. When the work requires additions or modifications to existing signal or lighting systems, the Contractor shall give the Project Manager and the maintaining agency at least two (2) working days advanced written notice of any interruptions and the maintaining agency shall be given the opportunity to inspect all work before and after the re-energizing.

- E. Salvage of Existing Material. Existing material which is designated for removal and salvaged shall be handled carefully to avoid damage and shall be delivered by the Contractor to the City's Traffic Operations Department or to a location designated in the contract.

605.40 TESTING OF NEW SYSTEMS

- A. Shop Testing. Controllers, Cabinets, and any specified Auxillary Equipment shall be Transported to the Traffic Services Signal Laboratory of the NMSHTD in Santa Fe, New Mexico to be tested for a maximum of thirty (30) days prior to the Project Manager's acceptance of compliance to specifications. The controller and cabinet furnished at this time shall be capable of operation with all load outputs and shall be complete in accordance with all contract requirements.
- B. Operation Tests. Before acceptance of the work, the Contractor shall make the following tests on all lighting and signal circuits:
1. Test for continuity of each circuit;
 2. Test for grounds in each circuit;
 3. A megger test on each circuit between the circuit and ground, including the insulation resistance for all vehicle loops, direct burial wire or cable; and,
 4. A functional test to demonstrate that all parts of the system function as specified or intended.

A thirty (30) day operational test period is required and will start when the traffic signal is completely installed and fully operational, including loop detectors. The Contractor shall request approval to start the thirty (30) day operational period, in writing, to the Project Manager and Traffic Operations Engineer. Tests shall be performed under the surveillance of the Project Manager and Traffic Operations Representative.

The Contractor shall provide access to the signal controller for the Inspectors during the test period. The Contractor shall furnish all electrical power, instruments, and personnel required for the test. Timing for

signal controllers during the installation test period shall be as shown in the contract. No signal shall be placed in operation until the Traffic Service Engineer has verified the time settings and the correctness of all signal indication outputs.

The initially applied voltage for the tests shall not be greater than the rated voltage of the cables, and the rate of increase shall be approximately uniform and not more than 100 percent in ten (10) seconds or less than 100 percent in sixty (60) seconds. All faults in materials or in any part of the installation revealed by these tests shall be replaced by the Contractor in a manner satisfactory to the Project Manager and Traffic Operations Representative, and the same tests shall be repeated until no fault appears.

A final inspection for the entire project will not be conducted until the thirty (30) day operational test period has been completed.

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SECTION 610

SIGNAL & LIGHTING SERVICE SYSTEMS

610.10 DESCRIPTION

This work shall consist of the installation of service poles, service connections, and lighting control cabinets in accordance with the specifications and the details shown in the contract.

610.20 SERVICE POLE

Timber poles shall be treated in accordance with the requirements of ASSHTO M133. Poles shall be of the size called for in the contract and as a minimum shall be butt treated.

Normal service requirements for traffic signals shall be 120/240 volt, sixty (60) cycle, three (3) wire solid neutral power, and for multiple lighting systems shall be 240/480 volt, sixty (60) cycle, three (3) wire solid neutral power, unless otherwise specified.

Service switches shall be a circuit breaker type or a disconnect switch, type HD, with fuses. The service switch shall be enclosed in a NEMA rain tight housing with a hinged cover. The cover shall stay in position when open and shall have a rasp for a padlock. The switch and housing shall be approved by UL.

A. Meter Pedestal. Materials for meter pedestals shall conform with the details shown in the contract, the requirements of NEC, and the following requirements:

1. Meter pedestals shall be constructed of fourteen (14) gauge steel with corrosion resistant finish.
2. Meter socket shall have minimum rating of 100 amp and be factory wired in separate wire way from terminal block to meter socket.
3. For services larger than 100 amp, a factory rated 200 amp pedestal shall be used.
4. Insulated stud terminal blocks or bus pads shall be used to accommodate connectors.
5. Pedestal bonding lug grounding conductors shall be continuous to the breaker panel grounding terminal.
6. Termination section shall have a removable rain tight cover with provision for padlock over captive pentahead bolt. All other removable portions of termination section must be sealable.

610.30 LIGHTING CONTROL CABINET

Materials for lighting control cabinets shall conform with the details shown in the contract, the requirements of the NEC, and the following requirements:

1. Cabinets shall be fabricated from 14 gauge steel with a corrosion resistant durable finish;
2. Cabinets shall be REA approved, ground mounted, tamper proof, and lockable;
3. Cabinets shall be suitable for 25 KV., systems with ground nut and ground lug;
4. Cabinet hardware shall be stainless steel including hinges;
5. Mounting brackets shall be furnished for attaching contractors, photo electric cells, junction boxes and other auxiliary equipment.

610.40 PHOTOELECTRIC CONTROLLER

The photoelectric unit shall consist of a light sensitive element connected directly to an internal control relay without intermediate amplifications. The unit may be either the horizontal sensing or zenith sensing type and shall have turn-on at 1.5 \pm 0.5 horizontal foot candles with a minimum difference of 0.8 foot candles between turn-on and turn-off. The load rating shall be 1800 watts minimum (HID load).

The base of the unit shall be provided with a three prong, EET-NEMA standard, twist lock type plug mounting which will enable the unit to be mounted directly on luminaries or by the use of an adapter base on pole tops or sides. The controllers shall normally work in conjunction with external auxiliary load relays for handling required lighting loads.

The supply voltage rating shall be the same as the system voltage noted in the contract. The minimum operating temperature range shall be minus forty degrees to one hundred forty degrees. The power consumption of the controller shall be less than twelve (12) watts.

When the north sky illumination in the area falls to a preset value, the lighting load shall be turned on. A potentiometer to vary the turn-on value within the operating range shall be easily accessible for adjustment. A time delay shall be incorporated into the circuit to prevent street lights from being turned off at night by transient lights which might be focused on the controller. The controlled lighting load shall remain on or become energized in the event of any functional failure of the electric circuit. The controller shall be equipped with a lighting arrestor capable of handling 500 V at 35,000 amps.

610.50 AUXILIARY CONTROLLER

The contractor shall work in conjunction with a photoelectric controller and the specified lighting loads. The contractor shall be normally open and shall be double pole. The contractor shall be of the electrically help type, designed to withstand lamp load inrush current and to carry full rated current on a continuous basis.

A three (3) position switch to permit manual operation of the lighting circuit shall be provided. The switch shall be furnished and installed with an indicating nameplate reading "PHOTO-OFF-MANUAL." The switch shall be toggled or rotary type, double pole, tripe throw, center-off position.

610.60 CONSTRUCTION METHODS

Service points shown in the contract are approximate. The Contractor shall obtain the exact location from the electric utility. The Project Manager must approve the final location before any service installation work is started. In the event a major change in location from that shown in the contract is required, the Project Manager will determine the final location and the service run will be adjusted.

The Contractor shall obtain all necessary permits and ensure that all electrical inspections required for service attachment are performed. Approval by the Project Manager must be obtained before hook-up.

A. Service Pole. Conduit shall be attached to the pole as shown in the contract. Plumbers tape, wire nails, or other means of fastening conduit will not be permitted. The conduit shall be securely bonded to the surface pole and the service pole ground system as required by the NEC. All conduits, covers, gaskets,

switches, fittings, and necessary equipment shall be furnished and installed. The layout, connections, and mounting details of the various switches and associated equipment shall be effected in accordance with the details shown in the contract.

Conduit used in the service installation above ground shall be rigid steel, galvanized type of the size specified in the contract. In areas where rigid steel conduit is couple to rigid PVC conduit used for the underground portion of the service run, joining of the conduits shall be made underground at a depth from two (2) inches to ten (10) inches below the surface.

The backing board shall be 3/4 inch thick Douglas Fir Grade B-B or better exterior type plywood. The plywood shall be painted with two (2) coats of approved good grade exterior grey paint for weatherproofing. Special care shall be taken to ensure that the edges of the plywood are well sealed against moisture and general weathering. Meter sockets are required by the service utility company shall be furnished and installed as shown in the contract. The service utility company will supply and install meters.

Service risers shall be installed on the quadrant of the existing pole as designated by the service utility company.

- B. Lighting Control Cabinets. Lighting control cabinets shall be installed plumb on concrete foundation with necessary grout or caulking to provide a weather resistant, dust tight installation. The installation of lighting control cabinets shall conform to the details shown in the contract.
- C. Final Operations Prior to Acceptance. After the signal has been placed in operation and prior to final acceptance, the Contractor shall ensure that the signal remains fully operational. The Contractor shall notify the Project Manager and the City's Traffic Operations Department immediately, and the Contractor shall effect emergency repairs if the signal malfunctions or is otherwise disabled. If the Contractor fails to respond to the emergency, the City's Traffic Operations Department may respond on an emergency basis, to ensure safe operation of the signal system. If the City's Traffic Operations Department responds to such an emergency, the Contractor will be responsible for all costs. Repairs of replacement of damaged signal of lighting systems due to the Contractors operations or negligence, shall be effected by the Contractor, at no additional cost to the City.
1. The electrical utility cost, maintenance and operational responsibility for existing signal and lighting systems for undergoing contract modifications shall remain with the maintaining agency unless otherwise designated in the contract.
 2. Maintenance of new signals and lighting systems shall be the responsibility of the Contractor until final acceptance of the project. The electrical energy costs of the signal and lighting systems shall be borne by the Contractor until acceptance of the system by the Department, after which the energy costs will become the responsibility of the maintaining agency. Upon final acceptance of the project, the City of Las Cruces will become responsible for the signal and the lighting systems operations and maintenance.

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SECTION 615

SIGNAL & LIGHTING STANDARDS

615.10 DESCRIPTION

This work shall consist of the installation of traffic signal and lighting standards, or anchor bolts when the contract calls for standards to be provided and installed by others, in accordance with the specifications and the details shown in the contract.

A standard shall consist of a shaft with a base, anchor bolts, mast arms, and other hardware required to support the traffic signal and highway lighting apparatus. Structures shall be designed to the requirements of the latest edition of AASHTO Standards Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals.

Hardware shall be either steel or stainless steel. Steel hardware shall conform to the requirements of ASTM A 307 or A 325 and shall be galvanized in accordance with the requirements of ASTM A 153. Stainless steel hardware shall conform to ANSI 300 series stainless steel.

615.20 TYPE I STANDARD

The pedestal type support shall be a threaded pole and a threaded (female) square cast aluminum base assembly with set screw(s). The aluminum base shall be approximately fifteen (15) inches high and shall have a covered hand hole of at least eight (8) inches by eighteen (18) inches in dimension. The pole may be fabricated from steel and may be either four (4) inches nominal diameter pipe, Schedule 40, or a tapered steel shaft of equal or greater wall thickness.

Type I Standards four (4) feet in height or less, shall be designed for a projected area of five (5) square feet. Type I Standards ten (10) feet in height or greater, shall be designed for a projected area of fifteen (15) square feet.

615.30 TYPE II & III STANDARDS

Standards shall be either of a monotube (single member) arm design fabricated from steel, or a "trombone" truss arm design fabricated from either steel or aluminum. Standards shall conform to the member attachment and size details in the contract for interchangeability and standardization between fabricators. The standard installation shall be designed to support traffic signal heads, back plates, dampers, and signing attached rigidly to the end of the arm.

A. Shaft. Steel shafts shall be fabricated from a weldable grade hot rolled steel, having a yield point, after fabrication, of at least 55,000 psi and a No. 7 U.S. Std. Ga. (0.1793 inch), minimum wall thickness. The shaft may be round or octagonal in cross section and tapered at a constant rate. After fabrication, the steel shaft shall be hot dip galvanized according to the requirements of ASTM A 123 and shall be cleaned to provide a uniform and stain free surface.

Aluminum shafts shall be fabricated from seamless round tapered tubing of alloy 6063-T6 or 6005-T5

conforming to the requirements of ASTM B 221, having a minimum thickness of 0.188 inch. The shaft shall have no welds except at the lower end joining the shaft to the flange base. The shaft shall be finished by mechanical means to providing a uniform appearance and shall not require any surface preparation at the time of installation.

A removable top pole cap or mast arm hand hole with cover shall be provided to allow access for the pulling of cable through the shaft.

- B. Arm. Monotube (single member) arms shall be fabricated from steel and “trombone” truss arms shall be fabricated from either steel or aluminum. The design projected area shall be twenty five (25) square feet and the design weight shall be 150 pounds. The type of arm furnished shall be as specified in the contract, and only that type of arm and material will be acceptable.

Material and finish shall be as specified for the shaft except that steel members shall all have a minimum thickness of No. U.S. Std. Ga. (0.1196 inch) and aluminum tubing used in the fabrication shall have a minimum thickness of 0.156 inch.

- C. Transformer Base. Steel transformer bases shall be fabricated from hot rolled mild steel having a yield point of at least 33,000 psi and side wall thickness of at least No. 7 U.S. Std. Ga. (0.1793 inch). The steel transformer base shall be galvanized after fabrication to the requirements of ASTM A 123.

The aluminum transformer base shall be a one (1) piece casting of aluminum alloy 256-T6 complying with the requirements of ASTM B 108. The bases shall be at least twenty (20) inches in height and shall have, in one (1) side, a hand hole with cover at least eight (8) inches by twelve (12) inches in dimension. The transformer bases shall be designed to permit the shaft to be rotated a full 360 degrees and to be aligned irrespective of anchor bolt placement.

- D. Anchor Bolts. Anchor bolts shall conform to the requirements of Subsection 615.40-B) Anchor Bolts. The top of each Type II standard anchor bolt shall be threaded at least (8) inches, and the full thread plus (6) inches shall be hot dipped galvanized.

615.40 STREET LIGHTING

Street Light Standards shall be tapered shafts with davit type mastarms. Dead load deflection shall be limited in accordance to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals., Subsection 1.91 (B)2a.

- A. Fabrication Requirements. The standard may be fabricated of spun aluminum, or galvanized steel.

1. Spun Aluminum.

- a. Shaft. Shafts shall be one (1) piece, seamless tapered tubes of alloy 6063-T6, conforming to the requirements of ASTM B 221. The shaft shall have a wall thickness of at least 0.188 inch for a mounting height of up to forty (40) feet and at least 0.219 inch for a mounting height greater than forty (40) feet. The shaft shall have no longitudinal welds and only (2) circumferential welds which shall be located at the lower end for joining the shaft to the anchor base. A one (1) piece cast aluminum anchor base of alloy 356-T6, complying with the requirements of ASTM B 108,

shall be secured to the base. All exposed edges of the plate which make up the base assembly shall be finished smooth and each base shall be furnished with four (4) bolt covers. The shaft shall be rotary sand polished and wrapped for protection during handling and shipping.

- b. Mast Arm. Mast arms shall consist of seamless aluminum tubing, alloy 6063-T6, of the length and shape shown in the contract. Arms shall be assembled by means of a slip fitter onto an adapter casting fixed to the main shaft and held by through bolts and set screws.
- c. Welding. Welding shall conform to the requirements of "Specifications for Aluminum Bridge and Other Highway Structures" published by the Aluminum Association.

2. Galvanized Steel.

- a. Shaft. Shafts shall be fabricated from steel having a yield strength of at least 40,000 psi after fabrication, with a minimum wall thickness of No. 10 U.S. S.d. Ga. (0.1345 inch), except that shafts with an after fabrication yield strength of 55,000 psi or greater may have a minimum wall thickness of No. 11 U.S. S.d. Ga. (0.1196 inch). The shaft shall be round in cross section and tapered at a constant rate. The shaft shall be a one (1) piece section and shall be attached by two (2) circumferential welds to a base plate. The base shall either be a one (1) piece steel casting or shall be fabricated from steel plate with a minimum yield strength of 36,000 psi.
- b. Galvanizing & Finishing. All exposed welds except fillet welds shall be ground flush with the metal base. All steel poles shall be fully galvanized after fabrication to the requirements of ASTM A 123. After galvanizing, the poles shall be cleaned to provide a uniform and stain free surface.
- c. Mast Arm. Arms shall be fabricated from the same material as the shaft and shall have a wall thickness of at least No. 11 U.S. S.d. Ga. (0.1196 inch). Arms shall be assembled by means of a slip fitter onto an adapter casting fixed to the main shaft and held by through bolts and set screws.

B. Anchor Bolts. Four (4) anchor bolts shall be furnished with each standard. The anchor bolts may be fabricated from high strength steel bars with a guaranteed minimum yield strength of 55,000 psi or steel meeting the requirements of AASHTO M 34. The bolts shall be sufficient size and length to support the structure with the design loads. Each anchor bolt shall have an "L" bend at the bottom. One (1) leveling nut and one (1) hold-down nut shall be provided with each bolt. Each anchor bolt shall be furnished with nuts and washers as required.

The top of the anchor bolts shall be threaded for approximately nine (9) inches and shall be galvanized for a minimum of twelve (12) inches. Each anchor bolt for Type V standards shall be furnished with nuts and washers as required for breakaway base utilized or one (1) nut, washer and shim(s) if an anchor type base is required.

C. Breakaway Bases. Type V standards shall be designed to meet requirements for dynamic performance under vehicle impact as specified in the AASHTO Standard Specifications for Highway Signs, Luminaries & Traffic Signals. All bases shall be designed for a sixteen (16) inch diameter anchor bolt circle pattern, unless otherwise specified. Type V standards to be located behind a barrier or bridge rail,

shall have an anchor base for direct, rigid mounting.

Steel standards may utilize a steel slip base or breakaway coupling. Aluminum standards may utilize either a cast aluminum base or breakaway coupling. If the total weight of the standard and the luminaire assembly exceeds 600 pounds or if requested by the Project Manager, the Contractor shall furnish evidence of compliance in the form of test data obtained in accordance with, "Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals."

Cast aluminum bases shall be inserted a minimum of twelve (12) inches into the shaft and shall be bonded to the shaft with weatherproof structural adhesive to fully develop the required strength.

Breakaway couplings shall be designed to be placed between the anchor bolts and the pole base, and of a frangible material that will breakaway under impact (shear). The coupling shall conform to the design and material detailed in the contract. The tensile and compressive strength of the coupling shall equal or exceed that required for the design wind loading of the furnished Type V standard.

615.50 CONSTRUCTION METHODS

Installation shall include the erection of standards complete as required in the contract, leveling of standards, required grouting between standard bases and foundations, and the installation of anchor bolts in foundations. Tolerance requirements for straightness of poles shall not exceed the values in Table 615.50-A.

**TABLE 615.50-A
STANDARD POLE STRAIGHTNESS TOLERANCES**

Total Mounting Height (Feet)	Straightness (Inches)
20	0.75
30	1.00
35	1.25
40	1.50
50	1.75

All threaded holes and hubs shall be retapped and sealed against rust by heavy grease or other type of preservative. Required field made holes (such as for mounting pedestrian push buttons) shall be neatly drilled. Use of a cutting torch will not be permitted. All scratches due to erection and handling shall be repaired in the field with a ninety five percent (95%) zinc rich paint.

When torque values are called for in the contract for anchor bolt nut, breakaway couplings or slip bolts, the Contractor shall make all adjustments with an approved torque wrench. Alternate torque values shall not be used unless approved by the Project Manager.

A. Street Light Standards. Davit arms shall be installed in accordance with manufacturer's recommendations to prevent rotation under wind loads. Through holes for the bolts in the top tenon shall be drilled in the field by the Contractor. If arms rotate after erection, the Contractor shall lower the Type V standard, reassemble the arm, and reinstall the Type V with the arm in the proper position.

- B. Existing Signal & Lighting Standards to be Relocated. Existing signal and lighting standards to be relocated shall not be removed until new foundations are in place and have been accepted by the Project Manager. The Contractor shall give the Project Manager and Traffic Operations Department at least five (5) working days notice before removing and resetting designated signal and lighting standards.

All shop drawings and other documents of record on the existing in place signal and lighting standards will be made available to the Contractor. All work and material required for rewiring relocated signal and lighting standards shall be furnished by the Contractor and included in this work. Any damage to the existing pole during removal and relocation of the standard shall be repaired or replaced at the contractors expense.

New foundations for existing signal and lighting standards to be relocated shall be supplied with new anchor bolts.

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SECTION 620

FOUNDATIONS INSTALLATIONS

620.10 DESCRIPTION

This work shall consist of constructing cast in place concrete foundations for support of traffic signal standards, luminaire standards, and control cabinets in accordance with the specifications and details shown in the contract.

620.20 MATERIALS

- A. Concrete. Shall be Class A and shall conform with the requirements of Section 500 Portland Cement Concrete. Furthermore, Cement, air entrainment and other admixtures, water, and aggregate shall conform with the requirements of Section 500 Portland Cement Concrete.
- B. Steel Reinforcement. Steel reinforcement shall conform with the requirements of Section 500.35 Steel Reinforcement.

620.30 PLACEMENT EXCAVATION

Foundations shall be placed on firm ground. If it is discovered during the excavation for a concrete foundation that the location shown in the contract conflicts with the existing underground or overhead utilities, a new location will be determined by the Project Manager if possible. The ground surface shall be restored to its original elevation if relocation is necessary. If the location can not be changed, a new foundation design or utility relocation will be provided by the Project Manager.

- A. Standard Foundations. Standard foundations shall be of the flush top variety unless otherwise shown in the contract. Foundations located in sidewalks shall be level with the surface of the sidewalk, and expansion material shall be placed between the foundation and the sidewalk. Foundations for standards with mast arms shall be carefully positioned so that the standards may be oriented as required in the contract.
- B. Ground Mount Foundations. Ground Mount Control Cabinet foundations shall be of the bench top type. Square pedestal cabinet foundation shall be flush top type. All anchor bolts shall be placed during concrete placement, properly located for the cabinet to be furnished. A Class A concrete base pad shall be placed in front of control cabinet foundations. The concrete pad shall be at least four (4) inches in depth by three (3) feet long by the width of the particular foundation, in dimensions. These pads shall be reinforced with welded wire fabric.

620.40 CONSTRUCTION METHODS

Cast in place forms shall be true to line and grade, rigid, and securely braced. The forms and ground shall be thoroughly moistened before concrete placement. The concrete for each operation shall be placed in one (1) operation. Exposed surfaces of concrete foundations shall receive a finish that is smooth, straight, and free of form marks.

Ground Rods shall be installed in accordance with NEC Ground Rod Installation requirements. When ground rods are called for in the contract to be placed in concrete foundations, the portion of the rod to be enclosed by the concrete shall be wrapped with three (3) layers of pipe insulation tape or placed through a one (1) diameter PVC conduit with a minimum of eight (8) feet of bare rod remaining in contact with soil.

A template shall be used to ensure that the conduit stubs and anchor bolts are held in proper position during concrete placement until the concrete has set. After placement and before setting of concrete, anchor bolts shall be raised and lowered individually to eliminate air pockets and to distribute aggregate, and shall be aligned properly. Rebar clearance of three (3) inches for cover shall be achieved by placing three (3) inch chairs between exposed earth and rebar.

Foundations shall be allowed to cure for a minimum of seven (7) days after concrete placement before standard erection may begin.

SECTION 625

RIGID ELECTRICAL CONDUIT

625.10 DESCRIPTION

This work shall consist of furnishing and installing rigid electrical conduit in compliance with the specifications and the details shown in the contract.

625.20 MATERIALS.

A. Nonmetallic Conduit. Nonmetallic conduit shall be high impact polyvinyl chloride (PVC) pipe, Schedule 40, Designation PVC 2110, conforming to the requirements of ASTM D 1785 or high density polyethylene (HDPE), Type III conduit conforming to ASTM D 1248-6. Conduit and fittings shall comply with the requirements on Underwriters Laboratories (UL) standards (Publication UL 651) and shall be stamped "UL Approved."

B. Metallic Conduit. Metallic conduit may be either galvanized rigid conduit (GRC) or intermediate metallic conduit (IMC). GRC shall conform to UL-6 specification, ANSI C80.1 and Federal Specification WW-C-581E, latest revision. Intermediate metallic conduit (IMC) shall conform to UL 1242 and Federal Specification WW-C-581E, latest revision.

Metallic conduit shall be hot-dipped galvanized to provide a corrosion resistant coating. Fittings shall be watertight and of the same material as the conduit. Approved expansion couplings shall be provided for all metallic conduit. Expansion couplings shall be as recommended by the manufacturer, and shall be design to compensate for linear thermal expansion of a run of metallic conduit. All expansion couplings shall make a watertight joint.

C. Liquid Tight Flexible Conduit. Liquid tight flexible conduit shall be made of an extruded polyvinyl jacket over a flexible hot-dipped galvanized core (Type UAG), UL listed and meeting NEC requirements.

D. Core Tar Tape. Coal tar tape for rust protection of galvanized rigid conduit shall consist of high tensile strength fabric saturated with coal tar pitch and shall contain a polyester film roll separator.

625.30 GENERAL CONSTRUCTION METHODS

All conduit to be installed underground shall be nonmetallic except where encased in concrete, such as bridge decks, or when called for in the contract. All conduit to be installed above ground shall be metallic. The Contractor may use conduit of a larger size than shown in the contract, at no increase in payment, provided the larger size is used for the entire run from the outer to outer. Reducing couplings will not be permitted.

Existing underground metallic conduit to be incorporated into new system shall be cleaned with a mandrel and blown out with compressed air. Existing nonmetallic conduit shall be blown out with compressed air. If excess amounts of foreign debris are encountered, conduit shall be flushed out with clean water and then

air blown as directed by the Project Manager.

- A. Conduit Routings. Routings of conduit runs shown in the contract are approximate and may be changed by the Project Manager to avoid underground obstruction. Accurate records of any change from conduit locations shown in the contract shall be kept for preparation of record drawings, and the details shall be submitted to the Project Manager before final acceptance of the project.
- B. Conduit Terminations. Conduit shall be terminated, stubbed, and capped when required. Metallic conduit ends shall be threaded and capped with standard conduit caps until wiring is started. Insulated metal ground bushings shall be provided for threaded ends when caps are removed and shall be electrically connected in accordance with the requirements of the NEC. All metallic conduit terminations shall be installed with bushings to prevent wire insulation damage during installation. Nonmetallic conduit ends shall be capped until wiring is started.

Conduit terminating in pole, cabinet, or pedestal bases shall extend a minimum of two (2) inches to a maximum of four (4) inches vertically above the bases.

Conduit entering a pull box shall terminate one (1) inch to three (3) inches inside the box wall and two (2) inches to three (3) inches above the top of gravel sump and shall be sloped to facilitate convenient pulling of wires and cables. Conduit entering through the bottom of a pull box shall be located near the sides and ends of the box so that the major portion of the box will be clear. Conduit shall enter from the direction of the run at all terminal points. Conduit shall enter boxes freely to allow for expansion and contraction.

- C. Conduit Bends. Conduit bends, except factory bends shall have a radius of at least six (6) times the inside diameter of the conduit. Bending radii and number of bends shall comply with the applicable requirements of NEC and local codes. The Contractor may use factory-made bends. Where factory bends are not used, conduit shall be bent without crimping or flattening, using the longest radius practical.

Metallic bends shall be used for difficult or long conduit runs to prevent damage to the conduit caused by pulling cables.

625.40 NONMETALLIC CONDUIT

Nonmetallic conduit shall be straight cut, and ends shall be squared and trimmed after cutting to remove rough edges. Connections shall be of the solvent weld type except for connections to metallic conduit where the coupling shall be threaded on the metallic conduit side. Solvent weld connections shall be made according to the recommendations of the conduit manufacturer. A bare No. 8 AWG copper conductor shall be run continuously in all nonmetallic conduit except when specified for communication cables. Expansion couplings shall be installed according to the manufacturer's diagrams and instructions.

- A. HDPE Conduit Extruded Over Conductors. Where permitted by local electrical codes, high density polyethylene conduit used for lighting and service runs may be manufactured by continually extruding it over the specified wire or cable called for in the contract. There shall be no adhesion between the wire or cable and the conduit. The Contractor shall obtain approval for this method from the electrical inspecting authority and provide proof to the Project Manager before installation.

B. Bending of Nonmetallic Conduit. The following methods may be used to bend nonmetallic conduit:

1. An even heat, not to exceed 300 degrees Fahrenheit is to be applied to a portion of the conduit wrapped in aluminum foil until desired flexibility is attained. Charring of the conduit shall be kept to a minimum.
2. The conduit is to be inserted into four (4) foot long water filled steel pipe heated to the temperature required to render the conduit pliable after (30) seconds or longer. The conduit is then to be removed from the hot water, bent as desired, and held in a jig for a cooling period of approximately twenty (20) seconds.

625.50 METALLIC CONDUIT

Conduit ends shall be reamed to remove burrs and rough edges. Field cuts shall be true and square so that ends to be joined will butt together for the full circumference. Conduit stubs, caps, exposed threads and conduit surface areas damaged during handling or installation shall be coated with a good quality bituminous material or other coating material suitable for the purpose.

Slip joints or running threads will not be permitted for coupling conduit. When a standard coupling cannot be used, an approved weatherproofed, threaded coupling shall be used. Non-threaded couplings may be used only when approved by the Project Manager. Conduit threads shall be thoroughly coated with a good quality rust preventative coating material before couplings are made up. Couplings shall be tightened until conduit ends are brought together and a good electrical connection is made throughout the entire conduit run.

625.60 GALVANIZED METALLIC CONDUIT

Galvanized metallic conduit shall be wrapped for rust protection when required in the contract. Rust protection shall be applied according to the following requirements:

1. Conduit surfaces shall be hand-wire-brushed to remove loose rust and scale, dust, and dirt. Oil and grease shall be removed with a suitable solvent.
2. The surfaces to be coated shall be warmed with a torch to remove moisture.
3. A suitable primer shall be brush-applied to the conduit surface before it has cooled. The protective coating shall not be applied until the primed surface had dried to a tacky consistency.
4. Coal tar tape, heated lightly with a torch to soften or bleed the pitch, shall be applied spirally to the conduit.

The coal tar pitch side of the tape shall be heated and applied to the surface of the conduit so that the polyester film becomes protective wrapping. No alternate type of tape material shall be applied unless approved by the Project Manager. Galvanized metallic conduit with a PVC jacket coating of 0.025 inch minimum thickness may be furnished in lieu of wrapping galvanized metallic conduit. Joints or couplings shall be coated with bituminous coating material, shall be wrapped after installation, with a minimum of three (3) layers of pipe insulation tape of 0.010 inch minimum thickness and shall be covered with mastic

compound.

Torn, cracked, or scuffed rust protection shall be repaired to the satisfaction of the Project Manager as specified herein. Repair material shall extend at least six (6) inches on each side of the damaged area.

625.70 INSTALLATION UNDER EXISTING PAVEMENT

Metallic conduit shall be installed under existing pavement by approved jacking or boring methods. Jacking or boring pits shall be at least two (2) feet from the edge of any type of pavement, measured from the side of the pit nearest to the pavement.

Nonmetallic conduit shall not be installed by jacking. Nonmetallic conduit may be installed by predrilling a hole larger than the conduit and hand installing the conduit.

Excessive use of water that might undermine pavement or soften subgrade will not be permitted. The Project Manager may approve relocation of conduit runs or pavement cutting when there is insufficient room for jacking or boring pits or when underground obstacles are encountered. Existing pavement, sidewalks, driveways, and landscaped areas shall be repaired to original or better condition, at no cost to the City.

625.80 CONDUIT FOR STRUCTURES AND FOUNDATIONS

Metallic conduit shall be rust protected to a minimum of six (6) inches inside a concrete structure or foundation. Rust protection will not be required for nonmetallic conduit.

A. Foundations. Approved coupling, as specified, shall be installed outside the concrete for future connections or removal on a metallic conduit run to a structure or foundation. Non-thread couplings will not be accepted.

If a pull box is located within twenty four (24) inches of a foundation, a coupling will not be required outside the foundation. Conduit leading to soffit, wall, or light fixture below the grade of the pull box, shall be sealed with an approved sealing compound. Light fixtures below the grade of the pull box shall also be sealed with an approved compound.

B. Bridge Structure. Conduit in bridge structures shall be installed as shown in the contract. Conduit to be embedded in concrete for abutments, piers, or bridge decks shall be metallic. Conduit shall be securely attached to the reinforcing steel by approved methods at intervals not to exceed four (4) feet. Conduit passing through abutment concrete shall be wrapped with two (2) layers of ten (10) pound asphalt felt building paper, securely taped or wired in place. Conduit runs on structure surfaces shall be secured by galvanized malleable iron clamps spaced no more than five (5) feet apart.

1. Expansion fittings as detailed in the contract shall be installed where conduit crosses a structure joint. The tubing shall be the same size as the conduit. Expansion fittings shall have a bonding number of No. 6 AWG flexible wire or approved equal. Where the Project Manager determines that expansion fittings or flexible tubing are not feasible, the conduit shall be installed in a watertight metal sleeve. The clearance between the outside of the conduit and the inside of the metal sleeve shall be one half (½) to one (1) inch.

2. Flexible Conduit. Liquid tight flexible conduit may be used between structure sections to accommodate for movement when called for. Liquid-tight flexible conduit may be installed within a concrete pour when approved by the Project Manager.

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SECTION 630 PULL BOXES & SPLICE CABINETS

630.10 DESCRIPTION

This work shall consist of furnishing and installing pull boxes or splice cabinets in compliance with the specifications and the details shown in the contract.

630.20 PULL BOX

Electrical pull boxes may be of concrete or reinforced plastic mortar, unless otherwise specified in the contract. Electrical pull boxes shall be of the dimensions required in the contract. Electrical pull boxes will be used in sidewalk, median, and natural ground areas and shall have open bottoms installed with provisions for drainage. All electrical pull boxes shall be designed for light vehicular traffic, AASHTO H 10 loading (5000 lbs. single axle over ten (10) inch area).

Non-concrete pull boxes shall be designed in accordance with the structural requirements of Western Underground Committee Guide No. 3.6, Incidental Traffic Loading (parts 4.1.3, 4.2.1 and 4.2.3).

Metal pull boxes shall be enclosed, watertight boxes for installation in bridge decks and other areas subject to vehicular traffic. When specified in the contract only this type will be acceptable. All metal pull boxes shall be designed to support, in place, an AASHTO H 20 loading (32,000 lbs. single axle over ten (10) inch by twenty (20) inch area.)

A. Concrete Pull Boxes. Concrete pull boxes shall be precast or reinforced concrete and shall be of the dimensions shown in the contract. Concrete pull boxes shall be reinforced with nine (9) gauge or thicker welded steel frame. Concrete for boxes shall consist of a mixture of 3/8 inch pea rock, washed sand, and Type II portland cement. The mixed concrete shall be thoroughly vibrated into rigid molds to form the boxes. Boxes shall be removed from molds twenty four (24) hours and shall be allowed to air cure for seven (7) days, minimum. Concrete shall have attained a minimum compressive strength of 3,000 psi after twenty eight (28) days. Chipped or cracked concrete boxes will not be accepted.

B. Reinforced Plastic Mortar Pull Box. Pull boxes made from plastic mortar shall be fabricated by a "sandwich" method. The outer layer shall be of fine sand and resin to provide a tough wear coating. The interior material shall be a sandwich of fiberglass reinforced plastic mortar consisting of coarse sand, graded sand and ortho-type polyester resin. The material shall have a minimum strength of 11,000 psi in compression, 1,700 psi in tension and 7,500 psi flexural strength.

1. The material shall conform to the requirements of ASTM D 543-167, Section 7, Procedure 1; ASTM D 756-56, Procedure E; ASTM D 1501-71, Section 6, Procedure B; ASTM D 570-63, Section 5, 6.1 and ASTM D 636-74.

The minimum acceptance criteria are retention of seventy five percent (75%) of control values for this testing with no visual cracking or surface pitting and, in addition, shall have been tested at -40 degree Fahrenheit and + 195 degrees Fahrenheit.

- C. Metal Pull Box. Metal pull boxes shall be of external recess flanged, closed bottom designed for flush mounting in concrete. Metal boxes shall be designed for vehicular traffic (AASHTO H 20 loading), except installations in sidewalk areas where the contract specifies a minimum of AASHTO H 10 loading design. Metal boxes shall be fabricated from cast iron with a hot-dip galvanized finish.

630.30 PULL BOX COVERS

Steel or cast iron covers shall be provided for reinforced plastic mortar pull boxes.

- A. Cast iron covers shall be constructed with reinforcing metal ribs running full length. Cast iron covers shall have a minimum weight of thirty five (35) pounds. Cast iron covers shall be provided with No. Bare copper ground clamps to attach grounds. Each cover shall be provided with flush lifting eyes and two (2) openings for bolting the cover down. The covers shall be designed as a minimum for AASHTO H 10 loading. When called for in the contract, a steel plate or cast iron cover AASHTO H 20 loading shall be provided. Cast iron covers shall be provided for concrete pull boxes.
- B. Metal pull box covers shall be of galvanized cross-ribbed cast iron or ductile iron, designed for the required loading. Metal pull box covers shall be fastened to the boxes with stainless steel or brass screws, sealed with a neoprene gasket providing a watertight NEMA 4 enclosure. Metal pull box covers shall have a checkered (non-slip) surface with prybar slots.

630.40 PULL BOX COVER INSCRIPTIONS

Pull box covers shall be inscribed or embossed "DANGER ELECTRICAL" or "ELECTRICAL" as detailed in the contract. In addition, a bead weld or other type or permanent lettering approved by the Project Manager shall follow this inscription to designate the specific circuit as follows:

LIGHTING	Lighting and Rest Area Electrical
TS	Traffic Signal
SC	Sprinkler Control

If the bead weld is used on a galvanized box, the effected area shall be coated with a zinc-rich paint.

630.40 SPLICE CABINET

The Contractor shall furnish NEMA 3R or NEMA 4 splice cabinets with back panel, splice bar, and Type I standard. Fabrication of splice cabinets shall be as shown in the contract. The splice cabinet shall be new, approximately twenty (20) inches by thirty (30) inches by eight (8) inches in dimension and shall be weather tight, fabricated from fourteen (14) gauge steel or 0.125 inch, minimum thickness, aluminum. Splice cabinets shall be furnished with a low voltage splice bar having fifty (50) units to the foot, with six (6) connectors per unit.

630.50 CONSTRUCTION METHODS

- A. Concrete Pull Boxes. Each pull box shall be installed so that the cover is flush with the curb or sidewalk grade and no part of the box or attaching screws protrudes above the surface. When no grade is

established, covers shall be placed slightly higher than the surrounding ground to provide drainage away from the pull box. The Contractor may install more pull boxes than shown in the contract to facilitate the Contractor's work at no additional cost to the City. Each pull box shall include a Class A concrete collar placed around the pull box and one-half ($\frac{1}{2}$) inch felt expansion joints as shown in the contract. Pull boxes shall be adequately supported by solid building blocks evenly spaced around the base.

- B. Metal Pull Boxes. Conduit entrances in metal pull boxes may be made in the field by a hole saw or as approved by the Project Manager. Metal pull boxes in bridge decks and pavement shall be installed flush with the pavement surface. Electrical pull box extensions shall be provided additional volume when called for and as detailed in the contract.
- C. Pull Box Sumps. Pull box sumps shall consist of two (2) inch maximum size rock fill surrounded by drainage geotextile. With the exception of metal pull boxes installed in concrete, all pull boxes shall have an eighteen (18) inch deep sump below the pull box. When pull box extensions are used with pull boxes to provide extra depth, sumps shall be thirty (30) inches deep. Excavation for boxes shall be of sufficient width to allow a minimum six (6) inch clearance on the sides of the boxes and extensions, with rockfill provided around outside walls. Class B drainage geotextile shall be placed between backfill and rock fill.
- D. Splice Cabinets. Splice cabinets shall be mounted on a Type I standard on a pedestal foundation.

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SECTION 635

WIRING

635.10 DESCRIPTION

This work shall consist of furnishing and installing wiring for traffic signal and highway lighting systems in compliance with the specifications and the details shown in the contract.

635.20 MATERIALS

Wire and cable shall conform to the requirements of the appropriate sections of IMSA Wire and Cable Specifications and the New Mexico Electrical Code and shall carry the UL label. The specified trade size for conductors is for copper. Only copper conductors of the trade size specified shall be furnished.

A. Multi-Conductor. Multi-conductors shall be polyethylene insulated, poly vinyl chloride or polyethylene jacketed, solid wire signal cable complying with the requirements of IMSA Specification 19-1 or 20-1. Special multi-conductor cable for direct burial or selfsupporting applications shall be furnished in accordance with the description and requirements in the contract. Conductors shall be No. 14 AWG size copper or as called for in the contract.

Conductor color coding shall be in accordance with Section 5.1 Table II of IMSA Specification 19-1 or 20-1 for unpaired conductor cables. Tracer color shall be molten dyed polyethylene co-extruded with the base color.

B. Single Conductor. Single conductors shall be moisture and heat resistant thermoplastic insulated electrical cable rated at 600 volts for installation in conduit and pipe. Conductors of No. 12 AWG size or thinner shall be solid copper complying with the requirements of ASTM B 3. The wire shall be uncoated unless otherwise specified. Conductors of No. 10 AWG size or thicker shall be stranded copper complying with the requirements of ASTM B 8, Class B.

C. Insulation. Thickness insulation shall conform to the requirements of ASTM D 2220 and NEC Table 310-13.

1. Conductors shall be insulated with THHN or THWN thermoplastic complying with the requirements of UL Standard for Thermoplastic Insulated Wires (UL 83). Conductor shall be factory tested to determine compliance to UL Standard for Thermoplastic Insulated Wire (UL 83). Conductors shall have distinctive, permanent markings on the outer surface for the entire length showing manufacturer, type of insulation, size of conductor, and voltage rating. Insulation shall be solid color or of basic colors with a permanent colored stripe the entire length of the conductor.

D. Communication Cable. Communication cable shall be paired polyethylene insulated, polyethylene jacket communication cable with electrical shielding, rated 300 volts, suitable for use in underground conduit. All communication cable shall conform to either IMSA specification No. 40-2-1990 (or REA specification PE-22 or PE-39). The conductor shall be No. 19 AWG copper, unless otherwise specified.

635.30 CONSTRUCTION METHODS

Wiring shall conform to the appropriate requirements of the NEC and State and local requirements. Wiring within cabinets, pull boxes, and pole bases shall be neatly arranged and laced. Powered soapstone, talc, or other inert lubricant may be used for inserting conductors into conduit. Bushings shall be installed on all metallic conduit ends before pulling wire to prevent damage to the wire insulation.

For each conductor or cable, a minimum of four (4) feet of slack shall be left at each signal or lighting standard and a minimum of two (2) feet of slack shall be left at each pull box. Ends of spare conductors shall be taped.

A. Identification. The phase or function of signal cable conductors shall be identified according to the insulation colors shown in the contract. Lighting circuit and signal service conductors shall be identified by black insulation. Two (2) ungrounded multiple lighting conductors shall have black or red insulation. Neutral and common wiring shall have white insulation

Identification tags shall be installed at cabinet, pull box, and pole locations where two (2) or more conductors or cables for different functions have the same insulation colors. Permanent tags of fiber or PVC shall be used for tagging wires.

All low voltage circuits for pedestrian push buttons shall be separate from 115 volt function conductors in a separate multi-conductor cable as identified at each splice point.

B. Terminals. Cable wires shall be secured to screw type terminals in traffic signal heads, pedestrian push buttons, and traffic controllers or as shown in the contract. Spade tongue type connectors shall be affixed to conductors using a tool specifically designed for connecting connectors to conductors.

635.40 SPLICES

Conductor splices will be permitted only inside of cabinets, and transformer bases with wiring access. Splices will not be allowed in pull boxes except for pull boxes for signals in medians. Connections of wiring within standards shall be at the appropriate terminals. No splicing of suspended cable used on span wire installations will be permitted. Soldered connections will not be permitted for splicing except for connection of loop lead in cable to loop detector wire. The entire splice shall be weatherproof. Splices shall be wrapped with all weather plastic electrical tape. When cables are pulled into conduit, the cable ends shall be taped to exclude moisture. The ends shall remain taped until splices are made or terminal appliances attached.

Communication cables shall be used for signal interconnect systems and splicing shall be at terminals or as shown in the contract. No other splicing shall be permitted.

Only spring type connectors shall be used for splicing 600 volt maximum conductors.

Only fused slice connectors shall be used for splicing 600 volt minimum conductors.

A. Spring Type Connectors. The wire ends shall be joined with an insulated spring type connector without soldering. A two (2) component, self curing epoxy resin shall be furnished in a double compartment

plastic envelope. The splice insulation shall be made by thoroughly mixing the components in the envelope and, after cutting open one (1) end of the envelope, inserting the wire connection into the epoxy resin and taping shut the open end of the envelope. Sufficient epoxy resin shall be provided to completely cover the connector and exposed bare wires at the connector.

- B. Fused Splice Connector. A fused disconnect splice connector shall be installed at each underground conductor in Type IV, V, and VI standard bases between the line and load sides on multiple lighting circuits. A similar unfused disconnect connector shall be installed between the load and line sides on the neutral when a neutral is used. Connectors shall be readily accessible from the standard base hand hole.

The splice connector shall enclose the fuse completely and shall be waterproof. The connector shall separate with the fuse held in the load side when the pole is dislodged. A receptacle type design shall be used for the line side housing to maintain insulation between the line side electrode and surrounding ground planes. Fused splice connectors may be single or dual housings. Splice connector terminals shall be rigidly crimped on to line and load connectors, using a tool recommended by the connector manufacturer. Terminals shall be insulated and made waterproof in accordance with the connector manufacturer's recommendations.

Fuses shall be standard midget ferrule type. Fusing for 400 watt lamps shall be three (3) ampere for 480 volt and 240 volt circuits and six (6) ampere for 120 volt circuits. Fusing for 1000 watt lamps shall be six (6) ampere for 480 volt and 240 volt circuits and ten (10) ampere for 120 volt circuits.

635.50 BONDING AND GROUNDING

- A. Bonding. Metallic cable sheaths, metal conduit service equipment, and metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire or copper strip of at least the same cross sectional area as No. 8 AWG. Metallic conduit in nonmetallic pull boxes shall be bonded by insulated grounding bushings and bonding jumpers. Metallic conduit in metal pull boxes shall be bonded by lockouts.

Standards and pedestals shall be bonded by a bonding strip attached to the lower portion of the shaft or base.

For nonmetallic conduit systems, a bare copper wire No. 8 AWG size or larger shall be run in and through all conduits, through all pull boxes, and to all poles. These wires shall be spliced at termination points and shall tie into neutral bars at service facilities or control cabinets to become true and functioning common bonds.

- G. Grounding. A ground rod (electrode) shall be installed at each multiple service point, each traffic signal standard, each cabinet foundation, and each luminaire foundation. Ground rods shall be 3/4 inch nominal diameter, installed such that at least eight (8) feet of the length is in contact with the soil and in accordance with NEC and IMSA specifications. Rods shall be driven vertically into the ground or as shown in the contract. Service equipment shall be bonded to the ground rod by a No. 6 AWG size copper wire. The portions of ground rods to be encased in concrete shall be wrapped with three (3) layers of pipe insulation tape (0.01 inch min. thickness) or placed through one (1) inch diameter PVC conduit.

Where a metallic conduit system parallels or crosses a permanent water system in accessible areas, grounding jumpers shall be installed at intervals not exceeding 500 feet. Grounding to a metallic water system at or near a service point will not be accepted in lieu of driven ground rods. One (1) lockout shall be used inside and one (1) lockout shall be used outside of each box when the box is not threaded.

SECTION 640

SIGNAL ASSEMBLIES

640.10 DESCRIPTION

This work shall consist of furnishing and installing traffic and pedestrian signal assemblies on signal poles and attaching base plates and directional louvers to traffic signals in compliance with the specifications and the details shown in the contract.

640.20 TRAFFIC SIGNAL ASSEMBLY

The number of signal faces (sections) in each traffic signal assembly will be shown in the contract. Signal faces shall be standard twelve (12) inch lens size. Signal assemblies shall meet the requirements of the latest edition of ITE Publication "adjustable Face Vehicular Traffic Control Signal Heads", in addition to the requirements contained herein. Signal assemblies shall be adjustable, colored light, vertical or horizontal type with the number and type of lights (faces) shown in the contract and shall be adjustable through 360 degree about a vertical axis. Signal assemblies shall be fabricated from either aluminum or polycarbonate resin material. The housing, and door shall be fabricated from the same material. Polycarbonate resin material shall withstand seventy (70) foot pounds of impact without fracture or permanent deformation.

All signal assemblies shall be designed so that back plates may be mounted. Vehicular signal assembly faces shall be covered after installation until the controller and intersection signals are placed into operation. The covering shall be black and installed securely enough so that there is no misunderstanding by the general public that the signal may be in operation.

A. Optical Units. An optical unit shall consist of a lens, a reflector, and a lamp holder with lamp. The optical units shall conform to ITE Standards and ANSI Standard D 10.1. Lenses shall be of the color shown in the contract, circular, with a visible diameter of twelve (12) inches. The design should produce outward and downward light distribution, with a minimum of light distributed above the horizontal. Lenses shall be true color, of best quality glass or polycarbonate resin material, free from imperfections, and of high illumination transmission.

A reflector shall be one (1) piece alzak aluminum. An opening shall be provided in the back of each reflector for the lamp holder. This opening shall be designed so that there will be no dark spots cast on the lens. Reflectors, lenses, and hoods shall be designed to reduce sun phantom to a minimum.

Lamp holders shall have a heat resistant molded phenolic housing and be designed to accommodate a 150 watt standard A-21 traffic signal lamp. The holder shall be capable of positioning the lamp at the exact focal point of the reflector. The lamp holder shall provide proper lamp filament orientation without affecting lamp focus.

B. Housing. A signal housing shall consist of an assembly of separate sections without tie rods, substantially secured together in a watertight manner to form the number of units required and provide a pleasing appearance. Each section shall house an individual optical unit. The housing of each section

shall be a one (1) piece, polycarbonate resin material with sides, top, and bottom integrally molded. Polycarbonate housing shall be a minimum of 0.090 inch thick and ribbed to produce the strongest possible assembly consistent with light weight and must pass ITE wind load testing. Each section shall include a one (1) piece hinged door, with mounting for the lens, and other parts of the optical system, watertight gaskets, and a simple non-corrosive door locking device. The optical system shall be mounted so that the various parts may be readily accessible or removable. Sections shall be interchangeable and constructed so that they can be removed or added. A round opening shall be provided in the top and bottom of each hole to receive a one and a half (1 ½) inch supporting pipe frame.

Each door shall be hinged and held securely to the body of the housing by two stainless steel hinge pins, eyebolt, washer and wing nut. Exposed screws and fasteners shall be noncorrosive. Interior screws and fasteners shall be fabricated from zinc plated brass.

A locking boss with seventy two (72) teeth shall be integrally cast or molded into the signal housing at both openings. The angle of the teeth shall be ninety degrees, and the depth of the teeth shall be 3/64 inch. The locking boss when used with other locking fittings of the same mesh or with or without use of an adapter, shall provide positive positioning of the entire signal head to eliminate rotation or misalignment.

A reflector and lamp holder shall be held in place by an aluminum reflector ring, pivoting so that it is independent of the door. The unit shall be designed so that the lamp may be replaced without the use of tools. Weather resistant neoprene gasketing shall be provided so the inside of the lens and reflector are sealed from dust and moisture. A terminal block shall be mounted in the back of the middle section of the signal assembly. The terminal block for all signal assemblies shall be a four (4) position, eight (8) terminal, barrier type strip at a minimum. The signal section leads shall be attached to the left of each terminal block. The opposite terminals shall be for the field wires. Wiring from each lamp holder shall be provided by two (2) coded leads with NEMA quick disconnect tabs. A white wire shall be connected to the shell of the amp holder. A black or colored wire shall be connected to the bottom or end terminal of the lamp holder. For identification, color coded leads shall be colored the appropriate red, yellow, or green, (yellow or green tracer for arrow indications), or, if black wires are used, the terminals to which the leads are attached shall be permanently marked as to the indication. Leads shall be No. 18 AWG size, Type TFF.

C. Visors. A twelve (12) inch nominal long tunnel visor shall be provided for each signal section. Visors shall be fabricated from 0.040 inch minimum thickness 3003-H16 corrosion resistant aluminum alloy sheet conforming to the requirements of ASTM B-209. Tunnel visors shall encircle the lens for 300 degrees with a four (4) inch open slot on the bottom. The visor shall have four (4) twist-on attaching ears for installation to the signal door by four (4) noncorrosive screws. The vertical outer face of the door shall have four (4) threaded holes equally spaced about the circumference of the lens opening and forty five degrees (45) from the horizontal or vertical axis so as to permit a vertical or horizontal installation of the signal assembly.

D. Frame Work & Mounting Brackets. Mounting brackets shall consist of assemblies on one and a half (1 ½) inch nominal size standard steel pipe and malleable iron, ductile iron, or brass pipe fittings. Securely assembled members shall provide plumb or level support. Conductors shall be concealed within framework, poles, and signal assemblies. Conductors entering assemblies from poles shall be

supported and protected by cable guides. Threads shall be coated with grease during field assembly.

- E. Backplates. Backplates shall be provided for signal faces with vehicular signal indications when shown in the contract. Backplates shall be anodized aluminum sheet of 0.058 inch minimum thickness or one (1) piece polycarbonate and shall be of a size to provide a five (5) inch border around the perimeter of the signal. Backplates shall be finished in accordance with the requirements of Subsection 640.215 Finish., part 2 Required Finish for Visors.
- F. Directional Louvers. Directional louvers shall be installed in signal visors as shown in the contract. Louvers shall be sheet aluminum and shall be made to fit snugly in the signal visors. Louvers shall be 11 3/8 inches in diameter and eight and a half (8 1/2) inches long and shall have a degree of cutoff from either side of the center axis of the light beam of ten and a half (10 1/2) degrees. Louvers shall be finished in accordance with the requirements of Subsection 640.215 finish., part 2 Required Finish for Visors.
- G. Traffic Signal Lamps. All incandescent lamps for signal assemblies shall be clear, ANSI designation A21, horizontal with medium base, 8000 hour minimum rated life traffic signal lamps. All twelve (12) inch signal assemblies shall be furnished 150 watt, 1770 average minimum initial lumens lamps and all incandescent pedestrian signals shall be furnished with sixty seven (67) watt, 660 average minimum initial lumens. Each lamp socket and lamp furnished shall be designed to position the lamp filament accurately within the reflector. (Light center length: 67 Watt-2 7/16 inches; 150 Watt-3 inches.)
- H. Pedestrian Sound Unit. A sound unit for blind persons shall be installed on "WALK", "DON'T WALK" pedestrian signal assemblies when specified in the contract. The pedestrian sound unit shall consist of a weather proof audio signal device operating continuously during the protected walk interval of the corresponding visual pedestrian signal. The pedestrian sound unit shall obtain the operating voltage (115 VAC) directly from the walk terminal in the visual pedestrian signal. The output volume of the pedestrian sound unit shall automatically adjust to the ambient noise level in the intersection. The unit shall be programmable and set to produce a "Peep-Peep" electronic bird chirping for east-west crosswalks and a "Cuckoo" electronic bird chirping for north-south crosswalks. The pedestrian sound unit shall be mounted facing toward the crosswalk and attached to the visual pedestrian signal per manufacturer's recommendations. The pedestrian sound unit shall meet the requirements of Table 712-A.

**TABLE 640.20-A
PEDESTRIAN SOUND UNIT REQUIREMENTS**

Characteristic	Requirements
Size:	Approx. 5"H x 3.75"W x 5"D
Weight:	Approx. 3 pounds
Power:	115 VAC plus/minus 22%, 60HZ, 3 watts
Humidity Range:	5% to 95%
Temperature Range:	-55 degrees Fahrenheit to +165 degrees Fahrenheit
Output:	90db @ 1 watt/1 meter
Color:	Flat Black
Output "Cuckoo":	Duration 0.6 seconds plus/minus 20% Freq. Base 1,100 HZ plus/minus 20%

Output "Peep Peep":	Freq. Dev. 120 HZ plus/minus 20%
	Duration 0.2 seconds plus/minus 20%
	Freq. Base 2,800 HZ plus/minus 20%
	Freq. Dev. 800 HZ plus/minus 20%

- I. Finish. When the signal assembly is fabricated of aluminum, the inside and outside surfaces of the signal housing, and door, shall be completely impregnated in the resin material, scratches shall not expose uncolored material. When the signal is fabricated of polycarbonate resin material, the required color shall be completely impregnated in the resin material, and scratches shall not expose uncolored material.

The visor and the outside surfaces of framework and mounting brackets shall be finished with two (2) coats of best quality oven baked paint, unless otherwise specified, as follows:

1. Signal housing, and door inside and out:
 - a. Signal Housing--Federal Yellow
 - b. Signal Door--Flat Black
2. Visor inside and out:
 - a. First Coat. Baked epon primer, zinc chromate or equal
 - b. Second Coat. Flat black urea baked enamel having zero glass reflectance. The dry film shall be a minimum of 0.001 inch thick.

640.30 OPTICALLY PROGRAMMED SIGNAL ASSEMBLY

Optically programmed traffic signal assemblies will be used instead of standard traffic signal assemblies at locations where it is necessary to limit the visibility zone of the indication. Optically programmed assemblies shall have the same general appearance and shall be mounted in the same manner as the standard assemblies shown in the contract and specified in subsection 640.21 Traffic Signal Assembly, except that lens faces shall appear square when not illuminated. The object lens shall provide a round signal indication when illuminated. Sufficient optical masking tape shall be supplied with each assembly to allow proper aiming of each section. Aiming of signal sections shall be done in the presence of the Signal Laboratory Inspector.

Optically programmed signal assemblies shall conform to the requirements for traffic signal assemblies, except as specified in this Subsection. Optically programmed assemblies shall permit the visibility zone of the indication to be determined optically and shall require no hoods or louvers. The projected signal may be visible or selectively veiled anywhere within fifteen degrees (15) of the optical axis. No indication shall result from external illumination nor shall one (1) indication illuminate a second indication.

The components of the optical system shall consist of a lamp, a circulet reflector, an optical limiter-diffuser, and an objective lens. The lamp shall be mated to the diffusing element by a circulet reflector with a specular inner surface. The optical limiter-diffuse shall be composed of heat resistant glass. The limiter-diffuse shall provide an imaging surface, at focus on the optical axis for objects at a distance of 900 feet to 1200 feet, and shall permit an effective veiling system to be variously applied as determined by the desired visibility zone. The limiter-diffuse shall have a positive means of indexing.

The objective lens shall be a high resolution planar incremental lens hermetically sealed with a flat laminate of weather resistant acrylic. Visors shall be nine and a half (9 ½) inches long cutaway type, finished in flat black. The lens shall be submetrical in outline and shall be capable of being rotated to any 0-degree orientation about the optical axis. Exteriors of the signal case, lamp housing, and mounting flanges, shall be finished in accordance to Subsection "Finish".

Lamp fixtures shall consist of a separately accessible housing and integral lamp support, a ceramic socket, and self aligning, quick release lamp retainer. The electrical connection between case and lamp holder shall be an interlock assembly which disconnects the lamp holder when open. Coded No. 16 AWG size lead wires of a length sufficient to permit solderless connection to line wires external to the signal shall be used.

The assembly shall mount to standard one and a half (1 ½) inch fittings as a signal section or a multiple section face or in combination with other signals. A rigid connection shall be provided that will permit the signal section to tilt from at least nine degrees (9) below the horizontal while maintaining a common vertical line through couplers and conduit. The assembly shall be mountable with ordinary tools and shall be serviceable without tools.

640.40 NEON PEDESTRIAN SIGNAL

Pedestrian signals shall be one (1) way signals in weatherproof vandal resistant and dust tight housing, designed to display the alternating symbol messages "HAND" in Portland Orange or "WALKING PERSON" in Lunar White. The assemblies shall be neon or incandescent, as specified. The Signal shall be a one (1) section signal assembly with symbols "HAND" and "WALKING PERSON" capable of displaying the alternate messages and conforming to the details in the contract and to the MUTCD. The signal shall be internally illuminated. The message shall be formed by painting (blackout) the message plate except for the area occupied by the eleven (11) inch high and six (6) inch minimum wide symbols. The messages shall blind out when not energized.

A. Housing. The housing shall be a one (1) piece corrosion resistant aluminum alloy casting with integrally cast top, bottom, sides, and back. An opening shall be provided in the top and bottom of the housing to accommodate standard one and a half (1 ½) inch pipe brackets. A shurlock boss shall be integrally cast into the housing at the bottom opening. Four (4) integrally cast hinged lug pairs, top and bottom, shall be provided for the door mounting. The housing door shall be a one (1) piece corrosion resistant aluminum alloy casting with integrally cast hinges. The door shall be attached to the housing by stainless steel spring pins. The door shall pivot or swing downward when opened. A gasket shall be provided between the door and the housing. Latching shall be by two (2) noncorrosive hinged bolts with captive wing nuts and washers.

The complete housing (assembly) shall be eighteen (18) to nineteen (19) inches wide, eighteen (18) to nineteen (19) inches high and nine (9) to ten (10) inches deep with the screen (visor).

B. Message Module. A message module shall consist of neon tubes, a molded white, acrylonitrile butadiene styrene or polycarbonate plastic tubing housing, and a screened message lens. The message lens shall be an integral assembly with the tubing housing, fitted with a neoprene gasket around its perimeter. Two (2) compartments shall be formed in the front of the module, enclosing and protecting the two (2) neon tube light sources. The material may be white or the inside of the tubing compartments

shall be painted with white acrylic paint to provide a protective background.

The tubing for the "HAND" symbol shall be a minimum of ten (10) mm diameter and shall be coated on the inside with fluorescent material producing the desired Portland Orange output. Tubing for the "WALKING PERSON" symbol shall be a minimum of nine (9) mm and coated on the inside for the desired Lunar White output. The tubing housing shall hold neon tubing in a positive location relative to the message plate so that a clearly readable message is provided. The tubing housing shall require no tools for removal or replacement. The tubing housing shall be provided with electrical contacts which will plug directly into recessed contacts or connect to flexible high tension leads by snap-on connectors. To reduce corona effects, flexible leads shall be of the minimum length necessary to allow the door to swing open.

C. Message Lens. The first coating of blackout paint shall be black and the second coating shall be white to reflect internal light. The message lens shall be one (1) of the following:

1. Ultraviolet stabilized polycarbonate plastic with external prismatic pattern, 1/8" inch minimum thickness.
2. Ultraviolet stabilized acrylic plastic with prismatic pattern, 3/16 inch minimum thickness.

D. Transformers. Solid state circuitry shall be assembled on one (1) or two (2) printed circuit boards, energizing two (2) high voltage flyback transformers for the respective neon tubes. The transformers and circuitry shall be in an enclosure behind the tube compartments providing protection from water penetration and physical damage.

The "HAND" and "WALKING PERSON" circuits shall require approximately thirty (30) watts with voltage range of 105 to 130 VAC. Each circuit shall be internally fused. Quick disconnect lugs shall be provided inside the housing for easy removal. A three (3) terminal pair, six (6) position screw type terminal block shall be provided for termination of field wires.

E. Screens (Visors). One (1) of the following types of screens (visors) shall be provided for each signal:

1. Z-crate type shall consist of a minimum of twenty (20) straight horizontal louvers and twenty one (21) horizontal louvers formed in a zigzag pattern. Every other formed louver shall be reversed so as to form cells one (1) inch squared, rotated forty five degrees 45 from the horizontal (diamond shaped cells). Each diamond shall then be bisected by insertion of a straight louver interspersed between each pair of formed zigzag louvers. Where each apex of each formed louver contacts a straight louver, the entire length of the joint shall be chemically welded. The material shall be nominally 0.030 inch thick, black polycarbonate plastic with a flat finish on both sides. The screen shall be enclosed in a 0.040 inch minimum thickness aluminum or polycarbonate plastic frame. The frame shall be one and a half (1 ½) inches deep and contain mounting holes for insertion in the door frame.
2. Eggcrate type screens shall be one and a half (1 ½) inches deep. Eggcrate type screens shall be 0.020 inch minimum thickness aluminum made of 3003 H 14 alloy conforming to the requirements of ASTM B 209 or 0.036 inch nominal thickness, polycarbonate. The assembly shall be mounted on an aluminum alloy or polycarbonate frame of 0.040 inch minimum thickness. The spacing between horizontal members shall be one half (½) inch (beginning near the top of the symbol) and

supported by a minimum of fifteen (15) vertical members.

- F. Fasteners. Exposed screws and fasteners shall be of ANSI Type 304 stainless steel. Interior screws shall be made of noncorrosive materials or shall be protected by cadmium plating. All screws shall have a flat black finish.

640.50 INCANDESCENT PEDESTRIAN SIGNAL

The incandescent signal shall have the same appearance as a neon pedestrian signal and shall, in addition to this specification, conform to the subsections of Neon Pedestrian Signal. The optical system shall consist of a two (2) section message lens, double parabolic reflector, lamps and lamp sockets, and a sun screen. The lens shall be located at least 1.75 inches from the closest extremity of the lamp. Lamps shall be ANSI Designation A21 Traffic Signal Lamps, sixty seven (67) watts.

The lens material shall be of 0.250 inch minimum thickness polycarbonate plastic with pattern texture on the outside or of 0.125 inch minimum thickness LUMASITE. The inside face of each message section shall be painted in the symbol areas with an appropriate transparent color to produce Portland Orange "HAND" symbol and a Lunar White "WALKING PERSON" symbol when illuminated. All other areas shall be painted black.

A neoprene gasket shall be provided around the perimeter so that a weatherproof seal is provided when the reflector, lens, door frame and case are properly mated.

Each molded, heat resistant lamp socket shall be accurately positioned so as to be centered and prefocused in its respective section of the reflector. The socket shall be pre-wired to a three (3) terminal pair screw type terminal block provided in the housing.

A single piece double parabolic reflector shall be formed from 0.250 inch minimum thickness polycarbonate plastic sheet. The lamp side shall be textured and reflectorized by vacuum deposition of an aluminum coating which in turn shall be protected by a hard wear resistant coating. The two (2) sections shall be divided by a full depth aluminum divider that properly mates with the message lens to prevent spillage between sections. Proper vent holes shall be provided in both sections.

640.60 CONSTRUCTION METHODS

Signal assemblies shall be mounted at the location and in the manner shown in the contract. Signal faces shall be plumb and level, adjusted to proper direction, symmetrically arranged, and secure after alignment. Overhead mast arm mounted in traffic signal assemblies will normally be mounted horizontally. When the contract call for an overhead signal assembly to be mounted vertically to a mast arm or span wire, the mounting bracket shall be as detailed in the contract. Backplates and directional louvers shall be installed on signal assemblies according to the recommendation of the manufacturer.

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SECTION 645

DETECTORS

645.10 DESCRIPTION

- A. Vehicle & Pedestrian Detectors. This work shall consist of furnishing and installing vehicle detectors in roadways and pedestrian push buttons on signal standards in compliance with the specifications and the details shown in the contract.
- B. Emergency Vehicle Optical Detector System Description. This work shall consist of furnishing and installing an emergency vehicle optical detector (EVOD) system at signalized intersections on signal standards and in control cabinets in compliance with the specifications and the details shown in the contract.

The emergency vehicle optical detector system employs optical communication to identify the presence of designated priority vehicles and cause the traffic signal controller to advance to and hold a desired traffic signal display selected from phases normally available.

645.20 LOOP VEHICLE DETECTOR

The loop vehicle detector shall be a self contained, electronic sensing device which registers the presence of a vehicle by recognizing inductance change in a loop of wire embedded in a roadway. The detector shall be rack mounted in a traffic signal controller cabinet, connected to the cabinet wiring through 44 terminal Cinch-Jones connector (50-44-30m) and wire harnesses. All detectors shall be the two (2) channel type with independent channel controls. When called for in the contract, each channel shall include a delay/extension time function and/or count function. All loop vehicle detectors shall in combination with this specification conform to NEMA standards for Traffic Control Systems, Part 15, 1989 Inductive Loop Detectors.

The two (2) channel construction shall ensure isolation of the channels, to allow elimination of "CROSS WALK" between adjacent loops by frequency selection. Period measurement detectors shall use alternate scanning to accomplish this isolation. The minimum composite loop inductive operating range shall be 50 to 1000 micro-henries and shall allow up to 1000 feet of loop lead-in.

Detectors may be self-tuning with automatic tracking or require initial tuning with a minimum automatic drift compensation range of plus or minus five percent (5%) after initial adjustment. Detector outputs shall be optically coupled. The output shall be fail safe (closed) in the event of power loss. The detector shall include a fail safe to call feature on each channel to provide a detect output in the event of open circuit loops.

- A. Operation. Operational selections or adjustments shall be made by digital or thumb wheel switches on the front panel. A minimum selection of three (3) frequency ranges and three (3) sensitivity (change in inductance) ranges shall be provided along with a presence or pulse output mode and a reset selector. Controls shall be separate and repeated for each channel. An output indication (LED) shall be provided for each channel and shall be located on the front panel.

B. Delay/Extend Operation. When specified in the contract, each channel shall include a digital timer to permit delaying or extending detection outputs.

Loop vehicle detectors shall include switches to select delay, extend/delay time, extension or timer off operation. Minimum range and steps shall be zero (0) to thirty (30) seconds in one (1) second increments for delay time and 0 to 7.5 seconds in 0.5 second increments for extend time.

Output indicators shall display difference in normal detection and delay/extend interval by flashing during this period or by two (2) indicators per channel, separating "CALL " and "DETECT". An external input for each channel shall be provided for the state of "GREEN" indication of the associated phase. When this "GREEN" input is true, it shall disable delay timing, and when false, extension timing shall be disabled. When detector logic inhibits times only on application of external signal (115 VAC), the external input shall be connected to the same phase red when the contracts calls for extend operation.

C. Two Channel Detectors. On a two (2) channel detector, both channels shall have active power inputs so as to permit either channel to be operated independently without the remaining channel connected. All connector terminal assignments shall comply with NEMA Standards Part 15.

D. Light & Transient Protection. All detectors shall meet the NEMA requirements for transient testing. This shall be accomplished through the use of metal oxide varistors (MOV) for protection from voltage induced in loop lead-in cables installed in the cabinet and flash over protection from internal circuit to ground.

E. Testing. The Contractor shall have the loop vehicle detectors transported to the Traffic Services Signal Laboratory in Santa Fe for testing and approval prior to the Project Manager's acceptance. The testing will be effected concurrently with the controller testing under Subsection 650.80-A *Testing*. The loop vehicle detectors will be inspected and tested as follows:

1. Sample testing for compliance to NEMA standards including: (a) Sensitivity, (b) Hold Time, © Long detection and recovery, (d) Adjacent lane rejection, and (e) Pulse Mode Rephase;

645.30 LOOP DETECTOR WIRE

Loop detector wire shall be used for installation in pavement saw cuts. All loop detector wire shall be No. 14 AWG stranded copper wire cross-linked polyethylene (XHHW) insulation conforming to requirements of IMSA Specification No. 51-3, 1991. Ducted loop wire shall be used for insulation in pavement saw cuts or by directly overlaying with pavement material. Ducted loop wire shall be loop detector wire loosely encased in a polyvinyl chloride to the requirements of IMSA Specification No. 15-5, 1984 except interior No. 14 AWG stranded conductor may either be insulated with polyvinyl chloride with a nylon jacket (THHN) or polyethylene (XHHW).

A. Loop Lead-in Cable. Loop lead-in cable shall be used to connect the loop installed in the pavement, to the loop detector unit installed in controller cabinet. Loop lead-in cable shall be No. 16 AWG copper, polyethylene insulated twisted pairs, shielded and enclosed with a polyethylene jacket. All loop lead-in cable shall conform to IMSA Specification No. 50-2, 1991.

B. Loop Detector Sealant. Loop sealant shall be used as a filler for loop saw cuts, and to secure and protect the loop wire. The sealant shall have sufficient strength and hardness to withstand the stress and abrasion from vehicular traffic, and still remain flexible enough to provide stress relief under terminal movement. The sealant shall also have the ability to bond to both concrete and asphalt, a rapid rate of curing so that the pavement bay be open to traffic in half (½) an hour after installation, an initial fluidity to permit installation in a narrow saw cut down to at least forty (40) degrees, a moisture insensitivity so that it may be applied to damp pavement effectively, and a resistance to vehicular fluids and road salt.

1. Hot Type Applied Loop Detector Sealant shall be a hot-melt, rubberized asphalt compound furnished in “bricks” which is formulated specifically to be stiff, non-tracking, flexible at low pavement temperatures, and suited for used as a sealant for traffic loop cuts. At application temperatures, sealant shall be a thin, free flowing fluid which pours easily, penetrates fine cuts, self-levels, and permits easy application. Sealant shall be melted and applied to pavements in accordance with manufacturer’s recommendations using either pressure feed melter applicator units or pour pots. Hot applied sealants shall meet or exceed the property requirements listed in Table 645.30-A, after curing.

**TABLE 645.30-A
HOT APPLIED LOOP SEALANT PROPERTY REQUIREMENTS**

Test	Procedure	Specification
Penetration, @ 77 degrees F, 100 g, 5 sec	ASTM D 1190	35, max
Softening Point	ASTM D 2398	180 F, min.
Ductility, 77 F	ASTM D 113	15 cm, min.
Mandrel Bend, 0 F, 180 deg., 5s, ½" dia.		Pass
Pour Temperature		380 F, min.
Safe Heating Temperature		380 F to 420 F

2. Cold Applied Loop Detector Sealant shall be applied by conventional cartridge gun or bulk handling pump equipment. The uncured wet material shall have a viscosity of 20,000 cps (approximately) at 77 degrees Fahrenheit using a Brook-field Viscometer, #6 spindle at 20 RPM, and have a nonvolatile content (solids) of seventy five percent to eighty five percent (75% -85%) by weight. The material shall cure a rate to allow, being driven over almost immediately after installation and be dry to the touch within twenty four (24) hours. The sealant shall be nonshrinking and remain flexible at temperatures down to minus forty degrees (-40). Cold applied sealants shall meet or exceed the property requirements listed in Table 645.30-B, after curing.

**TABLE 645.30-B
COLD APPLIED LOOP SEALANT PROPERTY REQUIREMENTS**

Test	Procedure	Specification
Hardness	ASTM D 2240-48	65-85
Tensile strength	ASTM D 414-68	500 psi., min.
Elongation	ASTM D 412-68	400%, min.
Adhesion (peel strength) (Canvas to Conc.)		

Arc resistance	ASTM D 49	71 secs., min
Dielectric strength @ 50-Hz	ASTM D 150	6.35, min.

The Contractor shall include, with material submittal lists, manufacturer's test data for listed physical properties, and installation recommendations. When requested by the Project Manager, the Contractor shall also furnish a sample for evaluation by the Traffic Services Section Signal Laboratory of the NMSHTD. Sealant formulas judged to have failed within one (1) year on either test or permanent installations, shall not be acceptable. Failure shall be considered excessive shrinkage, cracking, peeling or bond failures to the pavement.

- C. Preformed Detector Loops. Preformed detector loops shall be factory assembled and pre-dimensioned loops containing two (2) or more turns of No. 16 AWG with type XLPE insulation or better. The required number of conductor turns shall be as specified in the contract. The preformed detector loops shall be fully encased in PVC pipe conforming to ASTM D 1785, or polypropylene conduit, or an approved casing providing better corrosion resistance and structural strength. Approval must be obtained from the Traffic Services Engineer, prior to installation.

The loops shall not break, crack, or crush when subjected to compressive loading of heavy construction equipment. All splices between loop-wire and lead-in shall be soldered and covered with heat shrink tubing within a section of pipe. Conduit shall be waterproofed with RTV or other approved sealant. Wire shall be packed with filler material so that no movement or twisting of wire occurs. Interloop splicing is not permitted.

When hot asphalt rubber is used as a sealant for filler, the wire shall be covered with polyester insulation rated for a minimum of 425 F.

When polypropylene conduit is used for the loop casing, it shall be made of copolymer PP SDR-9 molded to the shape required. The corners shall be hot molded ninety (90) degree bends which are all integral to the loop conduit. Tees shall be provided at center connection quadrupole loops. All tees shall be CPVC heavy wall injection molded.

- D. Microloops. Microloops shall be a small, cylindrical unit designed to be installed beneath the road surface which shall be capable of being connected to an inductive loop vehicle detector to provide pulse mode vehicle detection. The microloop shall have a sensitivity of approximately 3.5 to 8 micro-henries / oersted at forty (40) kHz and 0.2 to 0.6 oersted ambient magnetic field.

The microloop probe shall be sealed for moisture protection and shall be capable of operating from minus thirty five degrees (-35 F) to plus one hundred and sixty five degrees (+165 F).

645.40 PUSH BUTTON STATION

The housing of the push-button station shall be of tamper proof construction and made of cast aluminum. The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather conditions. The housing shall be shaped to fit the curvature of the pole to which it is attached and shall provide a rigid installation. The housing body shall contain a direct push type

actuator button, micro-switch type or approved equal. The housing cover shall be fit snugly on the housing and shall contain the push-button sign. Push-button housings shall be finished with two (2) coats of best quality infrared ovenbaked paint as follows:

1. First Coat. Baked epon primer, zinc chromate or equal.
2. Second Coat. Federal yellow alkyd urea baked enamel matching Federal Standard 595A Color Chip 33538.

Pedestrian push-button signs shall be porcelain enameled sheet steel of 0.036 inch minimum thickness or sheet aluminum of 0.063 inch minimum thickness and shall be nine (9) inches by twelve (12) inches in size.

If porcelain enameled steel signs are used, each hole shall be provided with a brass grommet. Sign corners shall be finished round. Instructions and arrows on the signs shall be black enamel on white enamel background, and the instructions shall be as shown in the contract.

A. Single Piece Cast Aluminum Pedestrian Push-Button Assembly. A single piece cast aluminum pedestrian push-button assembly composed of a push-button assembly, pedestrian sign, sign frame and mounting saddle shall be used when shown in the contract. The push-button shall have silver contacts rated at thirty five (35) amps at twelve (12) volts and shall be constructed in such a fashion to prevent vandalism and freezing in inclement weather. The casting shall include a raised legend suitable for visually impaired pedestrians.

The single piece pedestrian push-button assembly shall be capable of being attached either by drilling and tapping the mounting surface or by using banding brackets as shown in the contract.

645.50 EMERGENCY VEHICLE OPTICAL DETECTOR SYSTEM

The system shall employ optical communication to identify the presence of designated priority vehicles and cause the traffic signal controller to advance or hold a desired traffic signal display selected from phases normally available. The matched set of components which make up the Emergency Vehicle Optical Detector (EVOD) system shall cause the existing traffic controller to be manipulated upon recognition of the signal from the vehicle.

This communication shall be effective to the optical detectors at or near the intersection over a line-of-sight path of at least 1800 feet. The EVOD system shall operate on a first come, first serve basis or on a selected priority basis. The EVOD system shall be designed to yield to other priority demands such as railroad crossings. The EVOD system shall interface with existing traffic signal controllers without compromising normal operation or existing safety provisions. The EVOD system shall consist of an optical emitter, optical detectors, optical detector cable, and phase selectors.

To ensure desired performance, the EVOD system shall provide matched system components, proven through integrated testing and extensive functional experience. The matched system components shall offer compatibility with all types of traffic signal controllers, i.e., electromechanical, or solid state. Matched components shall provide future system compatibility of all priority control elements.

- A. EVOD Optical Emitter Assembly. EVOD optical emitters shall be a light weight, weather resistant, light emitting device with internal regulated power supply. The optical emitter assembly shall produce precisely timed, crystal controlled optical energy pulses of high intensity from a single source, at a rate of 14.035 Hz or 9.639 Hz depending on the emitter control switch employed.
- B. EVOD Optical Detector. EVOD optical detectors shall be light weight, weatherproof, adjustable, single or dual directional optical detector assemblies. Internal circuitry shall transform optical energy from the optical emitter assembly into electrical signals for delivery (up to 1000 feet) via optical detector cable to the phase selection equipment.

This unit shall be of high impact polycarbonate construction with noncorrosive hardware and shall be designed for simple mounting at or near an intersection on mast arm, pedestal, pipe, or span wire and shall operate over an ambient temperature range of minus thirty degrees (-30) C to plus sixty (+60) C.

The unit shall be responsive to the optical emitter at a distance of at least 1800 feet and shall be capable of providing the necessary electrical signal to the phase selector through up to 1000 feet (305m) of optical detector cable.

- C. EVOD Optical Detector Cable. EVOD optical detector cable shall be durable, and shall have the necessary electrical characteristics to carry power to the optical detector from the phase selector and to carry the optical detector sign to the phase selector.

The cable shall have three (3) conductors AWG 20 (7 x 28) stranded and an individually tinned drain wire to provide signal integrity and transient protection. Cable conductors shall be copper and shall be shielded with aluminized polyester. The shield wrapping shall have a twenty percent (20%) overlap to ensure shield integrity following conduit and mat arm pulls. The cable shall deliver the necessary quality signal from the optical detector to the phase selector over a non-spliced distance of 1000 feet (306 m). The cable shall deliver sufficient power to the optical detector over a non-spliced distance of 1000 feet (306 m). The cable insulation rating shall be 600 volts, minimum. The cable temperature rating shall be eighty degrees (80) C, minimum.

The cable shall be color coded as follows:

1. Orange for delivery of optical detector power (+);
2. Blue for optical detector power return (-) or optical detector signal;
3. Yellow for optical detector signal;
4. Bare for optical detector power return (-).

- D. EVOD Phase Selector Assembly. The EVOD phase selection assembly shall interface between the optical detectors and the controller unit, shall not compromise the existing controller unit's fail-safe provision and shall provide sufficient power for up to three (3) optical detectors per channel. The assembly shall provide suitable sensitivity to the optical detector signal via adjustable range potentiometers. The assembly shall be a plug-in, two (2) channel, dual priority device intended to be installed directly into the input file of control cabinets equipped with priority phase selection software. The assembly shall be powered from AC mains and contain an internal, regulated power supply to power optical detectors.

The assembly shall have a test switch for each channel to deliver Frequency I (9.639 plus/minus 0.119 Hz) or Frequency II (14.035 plus/minus 0.255 Hz) signal pulse rates to verify proper function at both optical emitter flash rates, first-come, first-served operation, and Frequency II override capability. The assembly shall have a selectable call dropout time of five (5) or ten (10) seconds, 0 to +2.5%.

The phase selector shall be a modular, microprocessor controlled, two (2) channel, four (4) phase, high priority device, expandable to a four (4) channel, eight (8) phase, dual ring controller. The phase selector shall continuously monitor all GREEN, WALK, and pedestrian clearance displays for a smooth transition from controller to phase selector interval timing.

- E. EVOD Reliability. All equipment supplied as part of the optical priority remote traffic control system intended for use in the controller cabinet shall meet the electrical and environmental specifications spelled out in the NEMA standards publication TSI-1983 part 2.

All equipment supplied as part of the priority control system intended for use in or on emergency vehicles shall operate properly over an ambient temperature range of minus thirty degrees (-30C) to sixty degrees (60C) and in air with relative humidity from five percent (5%) to ninety five percent (95%) and a vehicle battery voltage from ten (10) volts to fifteen (15) volts.

645.60 LOOP DETECTOR INSTALLATION

The installation of loop detectors consists of two (2) distinct elements. The first element is the installation of the loop (inductive coil) in the pavement, at the location and geometry shown in the contract, including a low inductance lead-in cable back to the control cabinet. The second element is the installation of the loop vehicle detector sensing unit in the control cabinet, including all wiring to output the presence of a vehicle. Loop detector (total system) installations will not be accepted by the Project Manager until it is demonstrated that the installation will accurately detect the presence of vehicles as required in the contract.

- A. Saw cuts. Sawcut shall be made in pavement to the dimensions and shape detailed in the contract, using an abrasive cutting wheel concrete saw. Saw cut shall be 2 1/4 inches to 2 1/2 inches deep and approximately one (1) inch wide. A 3/8 inch wide slot shall be used to install ducted loop wire. When a contract includes new pavement or additional paving material overlay, the saw cut and wire installation shall be made at least below the last paving lift of 5/8 inch or greater thickness. No saw cuts will be permitted in final lift of surfacing. In the case of pavement overlay, the saw cut shall be a minimum of 2 inches below the final surfacing elevation. When the contract calls for heater scarification pavement treatment, the saw cuts shall be made after this operation has been completed.

Two (2) inch diameter holes drilled at angle points to the same depth as saw cuts shall be provided. Forty five degree (45) angle cuts made at corners will be permitted in lieu of drilled holes. Sharp corners between overlapping saw cuts of over forty five degrees (45 degrees) will not be permitted. Cuts across concrete pavement expansion joints shall also be drilled at this point to allow wire slack. Saw cuts shall overlap by a sufficient length to provide a smooth bottom, even depth wire channel.

When there is more than one (1) loop terminating at a pull box, each loop shall have a separate saw cut back to the box and these saw cuts shall be no closer than six (6) inches.

Before placement of the sealant and wire, the saw cut shall be cleaned of all debris and standing water by blowing out with compressed air. The pavement surface may be damp to the touch. The inside of the saw cut shall be free from any sharp protrusions such as from loose aggregate or uneven saw cuts.

- B. Rigid Electrical Conduit Entrance. A separate one (1) inch rigid electrical conduit entrance shall be provided at the pull box for each loop. The rigid conduit shall begin at the end of the pavement saw cut and run under any curb and gutter and sidewalk in conformance with the details shown in the contract. Wire through the conduit entrances shall be left slack and the end of the conduit shall be sealed with a soft-setting butyl rubber or asphaltic joint sealer. The remaining portion of the hole shall be filled with the appropriate material and approved saw cut sealant.
- C. Loop Wire Placement. A continuous run of loop wire shall be placed in the saw cut, wound around the coil section the number of turns shown in the contract as directed by the Project Manager. No more than four (4) wires or turns shall be placed in a single saw cut. Loop detector wire pairs shall be twisted, four (4) to six (6) twists per foot, between the loop, through the lead-in saw cut and conduit, to the shielded lead-in splice.

Wire run through drilled corners and joint crossing shall be left slack. This slack portion of wire shall be encapsulated with a soft-setting butyl rubber or asphaltic joint sealer.

Ducted loop wire may be installed during a paving operation by securely attaching the loop in the proper shape to the pavement surface and overlaying with the next paving lift(s) of two (2) inches or greater total thickness. Means of securing the loop, before overlaying may be by placing the ducted wire in slot cut in the pavement or by securing the corners by a method approved by the Project Manager, then covering the wire by hand with a small amount of asphaltic paving material. Ducted loop wire shall not be bent less than a one (1) inch radius.

- D. Sealant Application. Sealant shall not be placed when the ambient temperature is below forty degrees (40 degrees Fahrenheit) or when precipitation is occurring or impending. Sealant placement shall be in accordance with manufacturer's recommendations. All sealant shall be placed in a saw cut by means of a special nozzle. The saw cut shall be filled to approximately 1/8 inch of the top. No spill over onto the pavement surface will be permitted and excess shall immediately be struck off.
- E. Multiple Loop System. When a multiple loop system (same channel) is used, adjacent loops shall be wound with opposite rotations. Rotation reversal may be accomplished by reversing leads at the pull box. The Contractor shall mark the beginning of the loop wire and the pull box before beginning the winding installation process to allow determining the direction of rotation. All multiple loops shall be connected in series to the lead-in cable at the pull box or splice point.

645.60 PREFORMED LOOPS

The Contractor shall provide completely assembled preformed loops designed for the installation type and compatible with the construction details, for the location(s) specified, which are able to withstand the weight of fully loaded construction vehicles and equipment. Installation shall conform to the manufacturer's recommendations, except that, if there is a conflict between the manufacturer's recommendations and the City's specifications, the more stringent requirements shall apply.

- A. Field installation in Portland Cement Concrete Pavement (PCCP) shall be spaced a minimum of two (2) inches above rebar and not more than six (6) inches from the road surface.
- B. When loops are to be installed in hot mix asphalt, a layer of sand shall be placed over the loops prior to overlay. The layer of sand shall be sufficiently thick to prevent melting of the casing, but not so thick as to be deleterious to the overlay.

645.60 LOOP LEAD-IN CABLE INSTALLATION

Loop lead-in cable shall be run continuously from the loop wire splice to the terminal in the control cabinet. No splices in the lead-in cable will be permitted. The drain (ground) wire in the lead-in cable shall be connected to earth ground at the cabinet end only. The ground wire at the curb side pull box shall be neatly clipped off adjacent to the end of the outer jacket.

Connections between the loop wire and the lead-in cable shall be soldered. Open flame torches will not be permitted for soldering. The splices shall be made waterproof by encapsulating the bared wire with a two (2) part sealant, 3-M#3570 connector sealant, or equal.

The splices shall then be wrapped with a high quality, all-weather electrical tape or approved self-bonding tape, overlapping the wire insulation approximately one (1) inch and of sufficient layers to equal one and one-half (1 ½) times the thickness of the original insulation. The outer jacket of the cable shall be sealed in a similar manner except the tape shall overlap the outer jacket by four (4) inches. The "V" splices formed shall be suspended high in the pull box to prevent immersion in water.

When ducted loop wire is used, sealant shall be applied at the end of the tube portion then wrapped with tape to prevent water entry.

645.60 INTEGRITY TEST CHECK

After the loop installation in the roadway has been completed, each loop shall be checked with a megger to ensure the integrity of the installation. The resistance of each loop shall be greater than 100 megohms under any conditions.

645.60 EVOD OPTICAL DETECTOR SYSTEM

EVOD optical detector systems shall be installed in accordance with the manufacturer's recommendations. The equipment manufacturer shall not modify the existing traffic controller unit beyond adding the necessary hardware to the traffic controller cabinet.

Prior to bid/quote activity, the manufacturer or its authorized representative shall be required to conduct field surveys of intersection control equipment to determine the most appropriate phase selection device for each location and to recommend locations for installing optical detectors. After an award, the manufacturer or its authorized representative shall be responsible for system documentation including the following: a.) Acquire all relevant controller information; b.) Determine the number of vehicle phases (greens); c.) Determine the desired greens form priority approaches; d.) Determine range configuration of each controller; e.) Establish pedestrian phase timing requirements; f.) Establish minimum green times for non-

priority phases; g.) Establish the manipulation method of each controller type; h.) Supply interface information to installer; I.) Assist in system check-out prior to purchaser's acceptance by verifying proper installation per recommended interfaces, verifying that optical ranges are properly set, and verifying that phase selector timings or controller software timings are properly set.

The Contractor shall provide appropriate training to the City's personnel and emergency vehicle operators for a duration of two (2) days to train and assist in trouble shooting, maintenance and system operation. The Contractor shall submit the complete training program to the Department for approval, fifteen (15) days prior to scheduling the training. The training program shall include, but not be limited to, working outlines of presentations and all manuals, handouts and other materials to be distributed during the training.

SECTION 650

TRAFFIC SIGNAL CONTROLLERS

650.10 DESCRIPTION

This work shall consist of furnishing and installing traffic actuated controllers, special auxiliary control equipment, and cabinets in compliance with the specifications and the details shown in the contract. These specifications together with the NEMA standards Publication No. TS-1-1989 or latest edition for Traffic Control Systems describe required features, functions, and test procedures for traffic actuated controllers.

650.20 TRAFFIC ACTUATED CONTROLLER

All controllers furnished shall be of a modular design microprocessor type, unless otherwise called for in the contract. Input/output electrical connections for all standard and special functions shall be multi-terminal, MS type plugs on the front of the controller, conforming to the latest NEMA Interface Standards, or shall be department approved controllers with RS-232-C standard input/output ports. RS-232-C ports shall be used for communications and special functions. All controllers shall meet all requirements for a solid state NEMA traffic actuated controller and shall utilize the latest state-of-the-art design employing microprocessor and CMOS logic circuitry.

All controllers shall consist of a main processor board (MPU) input/output interface, and power regulation. The power transformer and capacitors may be rigidly fixed to the frame. Modules shall be easily removable from the controller. Battery backup shall be provided in the same module for the purpose of power down clock operation and battery backed RAM for non-programmed data, such as message logs.

The keyboard and LCD displays shall be on the front of the controller. Provisions shall be made in the design to allow time base coordination and preemption programming through the controller keyboard. The ports shall be capable of printing out program data to a stand alone printer; direct interface with a personal computer for unloading and downloading program data; and direct interface with a dial-up modem for remote communications with a personal computer over telephone lines to the signal operation. All controllers shall have LCD alpha-numeric displays for timing, status, and programming information. Each ring shall be provided with a separate display (simultaneous dual ring display).

The display shall have two (2) modes of operation (run and program). In the run mode, current phase, interval, and interval time remaining shall be displayed. In the programming mode, the phase, interval or programmable function, and the time or value shall be displayed.

A. Programming Requirements. All controllers shall use a key board for entry of all operator timing and functional data into nonvolatile memory. The keyboard shall be of a type providing tactile feedback when depressed. The procedure required to enter, revise and display operator data shall be menu driven and designed to minimize the number of key strokes; all key functions shall be marked on the front of the controller, clearly visible and easily readable by the operator. The display shall be LCD with adjustable contrast and backlighting. The operator data shall be retained in memory for a minimum of thirty (30) days after removal of primary power.

All controllers shall be capable of being programmed in different patterns of phase sequences: quad-left, sequential, or combination of concurrent and sequential. All controllers shall permit programming of phases as inactive. The signal plan shall be preprogrammed by the manufacturer as called for in the contract. This signal plan (sequence, inactive phases, any overlaps and/or preempt sequences) shall be non-volatile (not held exclusively in RAM). All programmed data shall be retained in non-volatile EEPROM.

The controller shall permit the display of an operator entered time or value before entering into memory, and shall provide for the automatic sequencing through the programming to minimize the required key strokes. It shall be possible to enter a four (4) digit numeric security code to prevent unauthorized changes under the programming mode. Access to view stored information shall be available at all times.

- B. Internal Preemption. Internal preemption shall be furnished for all controllers, providing railroad or emergency vehicle preemption sequences. Preemption shall provide as a minimum, six (6) independent preemption programs. It shall be possible to prioritize preemption, delay before preemption, cycle during preemption by hold phase assignments, and provide for pedestrian clearance through initial clearance yellow. All intervals to preemption shall be timed and all operator data shall be programmed through the controller keyboard. All operator entered preempt data shall be made available on the printer hard copy. The furnished preempt sequencing and operation shall be as called for in the contract. All railroad preemption shall be in conformance with MUTCD requirements and include a track clearance phase. Return to normal controller operation shall be in accordance with the plan phasing diagram and a detector call shall be placed on phases as noted.
- C. Internal Coordination. Internal time base coordination shall be furnished for all controllers providing the synchronization and control functions for coordinating actuated signalized intersections without the use of interconnecting cables. Coordination shall be made on a time of day, day of week and week of year basis. The coordinator shall function as a standard signal system coordinator using Force Offs, Holds and Phase/Ped Omits outputs and Phase Green inputs, capable of supervising the controller. The coordinator shall keep to the accuracy of the AC line frequency, and without line voltage to accuracy of at least plus/minus 0.005% (plus/minus 50 ppm).

The battery backup shall maintain real time and memory for at least 720 hours. The time clock shall keep track of time of day in seconds, day of week and week of year. It shall be possible to program for automatic Daylight Saving Time changes. In the event of a power disruption, the coordinator shall automatically upload itself upon return to line voltage. The coordinator shall have the minimum availability of 160 program changes, selectable on the minimum basis of ten (10) daily program groups, two (2) weekly programs, and (10) exception day (holiday) programs. The program change (on or off of any single function) shall be selectable at least to the minute of any hour of a day.

The coordinator shall have minimum selectable system options of four (4) cycles, four (4) splits per cycle, three (3) offsets per cycle, three (3) permissive periods per split, one (1) pedestrian permissive period per split, and three (3) force offs per split. Cycle settings shall be selectable from 0 to 255 seconds in one (1) second increments, or as a percentage of the cycle length. Offsets, permissive periods, and force off points may be programmable from 0 to 255 seconds in one (1) second increments or as a percentage of the cycle length. Offset seeking shall be selectable for dwell or short way offset transitions.

It shall be possible to manually select any program. The coordinated phase(s) shall be selectable and shall be programmed as called for in the contract. Display(s) shall be provided to allow the user (with keyboard control) to display the current time of day, week of year, cycle countdown, current plan in effect, hold, force off, sync outputs, and all programmed data as they occur.

- D. Components. All timing circuits shall consist entirely of solid state electronic circuitry consistent with the state-of-the art large scale integration circuit (LSI) techniques. The Contractor shall furnish cross reference and data sheets showing the parameters of all solid state devices used. All switching functions shall be accomplished through the use of solid state electronic circuitry. No electromechanical devices, such as rotary, stepping, or line-switches, or time/break relays, shall be used for switching functions.

All printed circuit boards (assemblies) shall be of glass epoxy, two (2) ounce copper circuit traces, conforming to NEMA requirements for traffic signal controllers. Current carrying traces shall be covered with a solder mask material, and those boards containing a major number of CMOS components shall be coated with a humidity sealant. In addition, circuit reference designation for all components shall be clearly marked immediately adjacent to the component. All components shall be amply derated with regard to heat dissipating capacity and rated voltage so that with maximum ambient temperature and maximum applied voltage, material shortening of life or shift in values does not occur. The design life of all components under twenty four (24) hour-a-day operating conditions in their circuit applications shall not be less than five (5) years.

- E. Constancy of Intervals. The controller shall be of such design that the length of any interval, portion, period, or unit extension may be set to two (2) significant digits and will be and remain within volts, the ambient temperature is between -30 degrees Fahrenheit and +165 degrees Fahrenheit, and the line frequency is sixty (60) hertz plus or minus 0.3 hertz. This performance shall include cold and hot starts and shall be obtained without the use of power consuming heating or cooling apparatus of any kind.

- F. Power. The controller and all associated equipment shall be designed for use on 115-volt, 60-cycle, single phase AC.

- G. Mechanical Construction. The controller shall be housed in either a sheet aluminum, steel, or approved housing with a durable finish. The controller shall be modular by design, conforming to microprocessor type specifications. Printed circuit boards shall be designed to plug into receptacles within the controller. Printed circuit boards shall be provided with secure fastening devices to prevent falling out during transportation or handling. All assemblies shall be interchangeable between controllers of the same manufacturer and series.

650.30 FUNCTIONAL REQUIREMENTS

Operator timing and functional programming shall be accomplished on the front panel of the controller. Programmed NEMA overlaps shall be internally provided within the controller. Operator programming shall be by keyboard entry. Each Phase Control Functions shall be capable of being set to the following functions:

1. Max Recall (Non Act): Automatically returns phase and extends green timing to that of max green. In absence of opposing phase demand, the controller shall rest in green.
2. Ped Recall (Non Act): Automatically returns phase to walk-ped clearance and vehicle right of way

- without vehicle and pedestrian demand.
3. Veh. Recall (Ext.): Automatically places a recurring demand for vehicle service without actual vehicle demand when not in its green interval.
 4. Non Locking (Memory Off): Phase operates in fully actuated mode; memory of vehicle demand is retained only when a vehicle is in the detection zone (detector outputting).
 5. Locking (Memory On): Phase operates in fully actuated mode; memory of vehicle demand (detector output) is retained in the phase until that phase is served.

650.40 OPERATIONAL REQUIREMENTS

- A. Timing Requirements. Each phase shall be provided with an extension control which shall provide vehicles added green time beyond the minimum green time by vehicle actuation(s). Successive actuations shall cancel the remainder of the previous extension interval and shall initiate a complete new extension interval for the vehicle which provided the actuation. Should transfer of right of way occur while an extension interval is unexpired, the right of way shall be returned at the next opportunity in the cycle.

Each phase shall be provided with at least two (2) maximum green timing interval controls which shall set a limit on the length of time that continuous traffic on the right of way phase can extend the right of way for that phase after an actuation is registered for any conflicting phase. Normal operation shall be in the (MAX 1) maximum interval. The second (MAX 2) maximum interval shall be effected by both an external and internal input. Each phase shall be provided with a clearance period. The clearance period shall consist of time intervals of the preset duration, namely: 1.) Yellow Change Interval. and 2.) Red Clearance Interval.

Actuation of a pedestrian push button during a pedestrian clearance interval or at any other time while the pedestrian "DON'T WALK" signal is being displayed shall register the presence of a pedestrian. This actuation shall be remembered so that the pedestrian walk indication will be accorded at the next assignment of right of way to the phase. In the event of a registered pedestrian actuation on a phase with no demand for pedestrian or vehicular right of way on a conflicting phase, the phase shall be capable of recycling and providing pedestrian and pedestrian clearance intervals. The minimum and guaranteed pedestrian protection shall consist of the pedestrian clearance interval. During the balance of the right of way and clearance intervals, the "DON'T WALK" shall be steady.

- B. Phasing Requirements. Right of way shall not be given to any street without an actuation (call) and, in complete absence of traffic (or recall option), right of way shall remain on the street where it was last assigned unless RED REST option has been exercised. The controller shall cycle to all red and remain until a phase call. All controllers shall operate as a concurrent phase timing (dual ring) controller, or sequential (single ring) configuration. All phases shall be identified (numbered) and operate in accordance with a NEMA dual ring (quad-left) configuration or sequential configuration. All controllers furnished shall be capable of operating at least eight (8) field phases. Controllers shall be capable of assigning the right of way to a single phase or any combination of non-conflicting phases, and shall normally operate in the mode specified in the contract. Phases skipped on each ring for no demand and recall functions for each phase shall be as specified for sequential controllers. Controllers shall have the capability of providing four (4) overlap phases in any phase combination, programmable on both a standard NEMA plug-in overlap program board and operator keyboard entry.

- C. Initialization Requirements. All controllers shall have an initialization control to start at the beginning of the programmed GREEN, YELLOW, or RED interval of the selected phase(s), as called for in the contract, application of power or the EXTERNAL START input. Vehicle and pedestrian calls shall be placed on phases.

650.50 TRAFFIC CONTROL SYSTEMS

- A. System Master. A system master shall be a traffic adjusted system master (arterial or multi-system as specified) of a microprocessor design. All units shall be shelf mounted in the controller cabinet with MS or RS-232-C type connectors, and shall be housed in a metal cabinet conforming to Subsection 650.215 Control Requirements.
- B. Closed Loop System. The closed loop system shall be a computer system which controls, operates, and supervises a traffic signal control system. The system shall consist of a computer facility, a communications network and field equipment. The Contractor shall contact the Traffic Design Section for preapproval of the system and components they proposed to supply with the closed loop system equipment. Failure to contact the Department will be grounds for rejection of the proposed equipment at the time of submission of the shop drawings.

650.60 EQUIPMENT

The components of the controller shall be provided in a sturdy, weatherproof metallic housing hereinafter referred to as a controller cabinet. Unless otherwise specified in the contract, all cabinets shall be wired for the full application of all phases, pedestrian signals on all through movements, and all normal overlaps for either four (4) phases-single ring operation, or eight (8) phase-dual ring operation. All vehicle detection shall be wired. The cabinet shall be furnished so that to implement any initially unused phases or functions, it shall only be necessary to add load switches, vehicles detectors, disconnect any jumpers and rearrange field conductors.

All ground mounted cabinets shall be #14 gauge sheet steel or 0.125 inch minimum thickness type 5052-H32 aluminum. Pedestal cabinets shall be aluminum of 0.125 inch minimum thickness. Cabinets shall be designed and manufactured for rigid mounting, whether intended for pole or pedestrian mounting. The cabinets shall not flex on their mounts. All cabinets shall be provided with lifting tabs. The specified types of controller cabinets and their internal components and wiring arrangements for a particular installation shall be necessary to provide a complete operating traffic control system as called for in the contract, and as described herein. All terminal blocks shall be barrier type.

- A. Cabinet Design. The cabinet shall have a main door which shall be equipped with a Corbin tumbler lock Number 1548-1, and an auxiliary door equipped with a treasury type lock Corbin Number R3575G5 for police key. The main door handle shall have provisions for padlocking in the closed position. A rain channel shall be incorporated into the design of the main door opening to prevent liquids from entering the enclosure. The cabinet door opening must be a minimum of eighty percent (80%) of the front surface of the cabinet. A stiffener plate shall be welded across the inside of the main door to prevent flexing. The top of the cabinet shall be incorporated a slope towards the rear to prevent rain accumulation. All seams shall be sealed with RTV sealant or equivalent material on the interior of the cabinet. The main door and police door-indoor shall close against a weatherproof and dust proof closed cell neoprene gasket seal.

The lower section of the cabinet door shall be equipped with a louvered air entrance. The air inlet shall be at least sixteen (16) inches by twenty (20) inches in size. Louvers must satisfy the NEMA rod entry test for 3R ventilated enclosures. A noncorrosive vermin and insect proof, removable air filter shall be secured to the air entrance. The filter shall fit snugly against the cabinet door wall. The main door hinge shall be a one (1) piece, continuous piano hinge with a stainless steel pin running the entire length of the door mounted on the right side when facing the cabinet. The hinge shall be attached in such a manner that no rivets or bolts are used.

Substantial metallic shelves or brackets to support the controller and auxiliary equipment shall be furnished and installed. A minimum of two (2) shelves shall be provided, unless approved otherwise. The shelves shall be adequately supported at both ends by angle-type braces. The shelves shall be of sufficient strength to prevent the shelf from sagging with the full weight of the control equipment.

- B. Control Cabinet Equipment Accommodation. Control cabinets shall be of sufficient size to allow the controller assembly and all associated equipment to stand in an upright position on the shelving. No equipment shall be placed on the floor of ground mounted cabinets. The control cabinet shall be of sufficient size to allow the removal of the controller assembly by pulling this assembly straight out. It shall not be necessary to turn the assembly sideways to remove it from the cabinet. The cabinet shall be of sufficient size to allow the door to be closed with no interference to the wire harness running to the floor. All equipment and wall mounted devices shall be capable of being removed without relocating or unjacking one (1) device to another device. Cabinet wiring shall be such that the front panels of control equipment are not obscured.
- C. Control Cabinet Dimensions. The minimum acceptable cabinet size shall be as shown in Table 650.60-A or as specified in the contract, provided that the space requirements of Subsection 650.60 A Control Cabinet Equipment Accommodation., are met.

**TABLE 650.60-A
REQUIRED CONTROL CABINET DIMENSIONS**

Type of Cabinet	Outside Dimensions		Use
	H	W x D (In inches)	
G	33	20 x 14	When called for on plans
M	48	30 x 16	When called for on plans
P	54	38 x 24	4 Phase single ring operation
P	54	38 x 24	8 Phase dual ring operation
R	72	38 x 24	When called for on plans

- D. Cabinet Finish. The outside finish shall consist of two coats with the first coat consisting of a four (4) stage iron phosphate coating and the second coat consisting of a TGIC polyester power coat paint matching Federal Standard 595A Color Chip 27886, with a min thickness of two (2) mm. The inside of cabinets shall be coated with two (2) coats of flat black primer.
- E. Cabinet wiring, Terminals, & Facilities. Wiring, terminals, and facilities within the cabinet shall be as described in NEMA Standards Publication No. TS-1, 1989, or latest NEMA standards and these

specifications.

All field flash sequence programming shall be accomplished at the field terminals with the use of a screwdriver only. It shall not be necessary to debuss field terminal blocks for flash programming. Field terminal blocks shall be wired to use four (4) positions per vehicle or overlap phase (green, yellow, red, flash). All cabinet wiring shall be neat and firm and all hardness and cabinet wiring shall be laced or bound together with Ty wrap or equivalent. All back panel wiring shall conform to the Table 650.60-B for gauge and color.

**TABLE 650.60-B
BACK PANEL WIRING REQUIREMENTS**

Description	Color of Wire	Gauge
Green / Walk load switch output	Brown	14
Yellow load switch	Yellow	14
Red / Don't Walk load switch output	Red	14
CMU (other than AC power)	Violet	22
Controller I / O	Blue	22
AC + (power panel to main panel)	Black	8
AC + (main panel)	Black	10
AC - (power panel to main panel)	White	8
AC - (main panel)	White	10
Chassis ground (power panel)	Green	8
DC ground	Grey	22
Flash programming	Orange	14

All wiring, 14 AWG and thinner, shall conform to MIL-W-16878/1, type B/N, 600 V, twenty nine (29) strand tinned copper. The wire shall have a minimum of 0.020 inch thick PVC insulation with clear nylon jacket and rated to 105 degrees Celsius, 600 V.

All connecting cables and wire runs shall be secured by mechanical clamps. Stick-on type clamps are not acceptable. Logic ground and chassis shall be isolated from each other within the cabinet. In addition, chassis ground and AC shall not be tied together within the cabinet. All wire at solder joints shall be hooked or looped around the eyelet or terminal block post prior to soldering to ensure circuit integrity. Lap joint soldering is not acceptable. All cabinet wiring shall be continuous from its point of origin to its termination point. Butt type connections / splices are not acceptable.

All back panel, D interface panel and detector panel terminal blocks shall be permanently numbered and labeled as to their function. All pedestrian push button inputs from the field to the controller shall be optoisolated or relay isolated to prevent transients and AC from entering the controller.

F. Back Panel. A back panel shall be provided for termination of all DC logic wiring. This panel shall be located on the back of the cabinet below the equipment shelves and shall include the load bay and the flasher/flasher relays. All terminals and plug-in units shall be readily accessible without moving any equipment. The back panel shall be a pre-wired type with the controller harness, conflict harness, and detector inputs permanently wired to the back of the panel. Connections for DC wiring shall be 1/4 inch quick connect tab type, 300 volt and twenty (20) amp rated. The wire shall be mechanically stripped 1/4

inch, with the tab firmly crimped covering wire and insulation, or shall be soldered. All AC connections on the panel back and all connections to the load switch/flasher receptacles shall be soldered.

All NEMA functions shall be brought out to the front of the panel with screw type connector. It shall be possible to program, on the front, using jumpers (clips or wires), the signal outputs for all types of phasing operations possible for the specified controller and access to all NEMA functions on the front for future auxiliary equipment. The terminal functions shall be clearly marked on the back panel with the appropriate NEMA designation. When auxiliary equipment logic is called for in the contract, these connections shall be made of the front of the panel.

The panel shall be mounted to the cabinet so as to allow sufficient clearance between the cabinet wall and the panel's back connections. It shall be possible to drop the panel in the field (access back wiring) using simple hand tools. The load bay, including flasher, shall be a rack mounted type. The load switches and flasher shall be adequately supported after insertion to prevent falling out due to vibrations.

The minimum positions for plug-in units shall be provided as listed in Table 650.60-C.

**TABLE 650.60-C
LOAD SWITCH / FLASHER UNIT POSITIONS**

Type of Cabinet	Load Switch Positions	Flash Relay Positions	NEMA Flasher
phase single ring	8	2	1
8 phase dual ring	16	4	1

- I. Power Distribution Panel. The power distribution panel shall be provided on the lower right-hand side of the cabinet and shall be fully enclosed to prevent accidental shock. The power panel shall include the main power feed terminal (barrier type), required AC protection from lightning (EDCO SPA-300 surge arrester or approved equal), filter (RFI), MOV to ground, with a removable cover, and any NEC requirements.
- J. Detector Panel. A detector panel shall be provided on the left-hand side of the cabinet. Terminal blocks (barrier type), with removable buss bars shall be provided for all detectors and pedestrian push-button field conductors as required in the contract. The detector rack shall include the "J" pin conductor appropriately terminated for extend / relay operation. The detector rack positions shall be provided in accordance with Tables 650.60-D, 650.60-E, and 650.60-F.

**TABLE 650.60-D
REQUIRED DETECTOR RACK POSITIONS**

Type of Cabinet	Detector Rack Positions	Detector Terminal Blocks
4 phase single ring	16	16
8 phase dual ring	16 to 32	16 to 32

**TABLE 650.60-E
4 PHASE SINGLE RING OPERATION**

**16 CHANNEL DETECTOR RACK
ORDER OF POSITIONING**

PH1	PH2	PH4	PH2EC	PH1	SD1	SD2	SD4
PH3	PH2	PH4	PH4EC	PH3	SD3	SD2	SD4

**TABLE 650.60-F
8 PHASE DUAL RING OPERATION
16 CHANNEL DETECTOR RACK
ORDER OF POSITIONING**

PH1	PH2	PH6	PH2EC	PH3	PH4	PH8	PH4EC
PH5	PH2	PH6	PH6EC	PH7	PH4	PH8	PH8EC

Connector / Pin assignments (2 x 22 pin edge card connector with 0.156 inch contact center, key slots located between B & C and M & N) shall be listed in Table 650.60-H.

**TABLE 650.60-H
CONNECTOR / PIN ASSIGNMENTS**

Connector/ Pin	Assignment
A=	DC (-) Common
1=	Call Delay Inhibit (Channel 1)
B=	DC (+) Power
2=	Call Relay Inhibit (Channel 2)
C=	Reset
4 & D=	Loop #1
5 & E=	Loop #1
F=	Output #1A Optocoupler (Collector)
H=	Output #1A Optocoupler (Emitter)
8 & J=	Loop #2
9 & K=	Loop #2
L=	Chassis Ground
S=	Output 1B AccuCount FET (Drain)
W=	Output 2A Optocoupler (Collector)
X=	Output 2A Optocoupler (Emitter)
Y=	Output 2B AccuCount FET (Drain)
Z=	Output #1C Fail FET (Drain)
19=	Output #2C Fail FET (Drain)

All pins not listed are spares.

1. A "D" connector panel with harness shall be provided with each cabinet assembly on the left hand side of the cabinet, fully wired to provide all functions. The panel shall contain provisions for mounting two (2) 120 VAC relays for preempt inputs 1, 2, and a 1/4 amp fuse for each relay.
2. A telemetry interface harness and printed circuit board interface panel shall be supplied with each cabinet assembly. The following input / output as a minimum, shall be accessible from the telemetry interface panel: A socket mounted communication line transient protection device shall be supplied with the telemetry interface panel. The transient protection device shall be wired in series with the

telemetry communication circuit. Communication line impedance shall be matched to the transmitter output impedance to minimize noise on the line.

LINES 1 & 2: Local controller command, Local controller read back, Master controller command lines, Master controller read back.

Chassis grounds

Four (4) special function outputs

Eight (8) system detector inputs

Flash input & CMU flash input

K. Wiring Diagrams. Four (4) sets of wiring diagrams shall be furnished for each cabinet. One (1) set shall be on mylar. The cabinet shall be equipped with a plastic envelope to house one (1) or more cabinet wiring diagrams. These wiring diagrams shall be furnished with the equipment submitted to the Department Signal Laboratory before testing will begin. The cabinet wiring diagrams shall show and identify the connectors for all equipment and switches, relays, flashers, etc. The diagrams shall also have a complete intersection sketch, with street names and north arrow including labeling of signal heads and detectors and a signal sequence chart identified and related to the intersection sketch.

L. Additional Required Terminals, Protection Devices, & Switches. The following additional terminals, protection devices, and switches shall be furnished for all cabinets:

1. A UL listed forty (40) amp circuit breaker for filtered AC power serving all solid state devices including load switches.
2. A separate twenty (20) amp circuit breaker for AC circuit serving the G.F.C.I. outlets, fan and light;
3. Copper ground strip, mounted and ground to cabinet wall, for connection of all common conductors;
4. All field signal output circuits shall be terminated on an unfused terminal block with a minimum rating of fifteen (15) amps. AC field terminals shall have a number 10-32 x 7/16 inch screw as a minimum.
5. Terminal blocks shall be provided to terminate a special equipment harness. These terminals shall be located on the right-hand side of the cabinet, above the power distribution panel;
6. Terminals for connecting interconnect cable tie points and intercabinet termination when required; Transient protection shall be provided on all external lines;
7. One (1) duplex G.F.C.I. convenience outlet shall be furnished for test equipment, tools, and lighting. A second duplex G.F.C.I. convenience outlet, wired to filtered AC power, shall be furnished for telemetry equipment. The outlets shall be NEMA Type 5-15R;
8. Main switch, identified "On-Off", wired to turn off signal light power when switched to off position and to de-energize the controller and auxiliary equipment; This switch, and connecting wiring, shall be rated at fifty (50) AMP minimum;
9. Auto flash switch, identified "Auto Flash", wired to keep controller energized and to place signals on flash when switched to flash position; The controller shall have stop timing applied when in the flash position;
10. The interior switches and convenience outlet specified shall be combined on a single panel and mounted on the inside of the cabinet door unless otherwise noted; All switches except main switch, shall be heavy duty and rated fifteen (15) amps minimum; Any exposed terminals or switch solder points shall be covered with a nonflexible shield to prevent accidental contact; All switch functions must be permanently and clearly labeled; All wire routed to the police door in door and test push button panel shall be adequately protected against damage from repetitive opening and closing of the

main door;

- a. Test Switch. A two (2) position switch, identified "Auto Flash," wired to de-energize the signal light power when switched to flash position and to permit the controller to cycle through its normal sequences while displaying flash indications on signals;
 - b. "Controller On/Off," Switch. Two (2) position switch, identified "Controller On / Off," wired to de-energize the controller and auxiliary equipment when switched to the off position.
 - c. Vehicle & Pedestrian Detector Switches. Two (2) position momentary switches labeled "ON, TEST" wired to each vehicle and pedestrian detector input for permitting the substitution of manual call into each controller detector input; Identify switches as to phase/function;
 - d. Preemption Test Switches. Test switches shall be provided to permit a manual preempt input. Each preemption phase shall have a separate switch with each phase appropriately identified.
 - e. Door Ajar / Open Switch. The cabinet shall include a door switch to log an event to the system master that the door is either open or ajar.
 - f. Fluorescent Light Door Switch. The cabinet shall include a door switch that turns the cabinet fluorescent light when the cabinet door is open.
11. Radio line filter (RFI) for filtering AC+ lights and control power for solid state light control and controller operation.
 12. Pedestrian push-button isolation (field circuit) shall be provided to protect solid state devices from transient voltages, i.e., prevent transients from being induced in the open pedestrian push-button circuits by isolation transformer(s), or by optoisolation.

M. Additional Cabinet Features.

1. Cabinet Fan. A fan shall be mounted in the controller cabinet and shall be thermostatically controlled and shall turn on at a cabinet temperature manually adjustable through a range of seventy degrees (70) to 160F. The fan and cabinet vent holes shall be located with respect to each other so as to direct the bulk of the air flow over the controller unit. The inside opening shall be covered with inch maximum mesh screening to prevent the operator from accidentally coming in contact with moving fan blades. The cabinet intake fan vent shall be filtered.
2. Fluorescent Light. A fluorescent fixture and lamp shall be mounted in the cabinet over the door, positioned so as to minimize damage when sliding equipment off shelves. The fluorescent fixture shall be for an F20T12 lamp in all ground mounted cabinets and for F15T12 lamp in pedestal cabinets. The lamp shall be packaged separately when transported to avoid breakage. The fluorescent light shall be turned on by the use of a door switch.
3. Door Stops. Each controller cabinet door is twenty two (22) inches or more in width or six (6) square feet or larger in area shall be provided with a stop to limit door opening to both 90 degrees and 180 degrees, +/- 10 degrees. The stop shall be provided with a catch which can be operated when the door reaches the extreme open position and which will hold the door open securely until released.

N. Solid State Signal & Pedestrian Load Switches. All signal load switches shall be external to the controller and shall be carried in the back panel load bay. In addition to these specifications, all signal control load switches shall conform to NEMA Standards TS-1, 1989 or latest NEMA standards. The signal control assembly shall consist of a separate plug-in unit containing the control circuitry for the operation of three (3) separate signal lamp circuits. Vehicle and pedestrian control assembly shall not be used for any other function or phase.

Circuitry shall consist of solid state electronic components. No mechanical relays shall be used for the opening and closing of signal light circuits or for any other purpose. The design of life of all

components under twenty four (24) hours per day operating conditions in their circuit application shall not be less than five (5) years. All load switches shall be rated at fifteen (15) amps, minimum. Each load switch shall include three LED indicators on the face of the switch, visible through the door opening of the cabinet, and connected to the input functions.

- O. Solid State Flasher. A solid state flasher, NEMA type 3, fifteen (15) amps, minimum, per circuit, dual-circuit, shall be furnished with each controller cabinet. The flasher shall be external to the controller and shall be carried in the back panel load bay. All solid state flashers shall conform to NEMA Standards TS-1, 1989 or latest NEMA standards. The flasher transfer relays shall be the normally open, multi contact plug type. A sufficient number of relays shall be provided to permit any combination of flashing RED or YELLOW indications. One (1) RC network shall be wired in parallel with each group of three (3) flasher transfer relays and any other relay coils. All flash transfer relays and any other relay coils. All flash transfer relay sockets shall be Cinch-Jones #2408SB or equivalent. It shall be possible to isolate the controller's DC signals to and from the load switches by the use of removable links. Modifications on the back of the main panel are not acceptable.
- P. Conflict Monitor (NEMA Plus). A conflict monitor unit shall be furnished with each controller. A signal monitors shall be the self-contained, shelf mounted with the appropriate NEMA MS connector(s). All conflict monitors shall conform to NEMA Standards TS-1, 1989 or latest NEMA standards.

Minimum monitor functions shall be as follows:

1. Conflicting GREEN, YELLOW, or WALK signal indication at the controller assembly field terminals.
2. Detect the absence of a required RED signal indication at the field terminal when the GREEN or YELLOW inputs of that channel are not active. The RED monitor point shall be made on the field side of the field output terminal.
3. Monitor opening voltage in the controller unit and the +24 volt DC inputs.
4. Simultaneous sensing of active GREEN and YELLOW or GREEN and RED signal indications on a channel.
5. Absence of an active YELLOW input for a preset period (2.0 to 2.8 second range) following the termination of an active GREEN input on a channel.
6. In the event of any of the previously listed faults, the monitor shall apply stop timing to the controller unit and transfer the signals to a flashing operation.
7. The watch dog monitor is used to ensure that the controller's processor is cycling by monitoring the Controller Flashing Logic Output.
8. GREEN or WALK vs. YELLOW. This feature is enabled by a single unit-wide switch (all channels). When enabled, all channels will monitor for GREEN or WALK indications on at the same time as the YELLOW for that same channel.
9. GREEN, WALK or YELLOW vs. RED. This feature is enabled on a per channel basis (individual switch for each channel). When enabled, the corresponding channel will monitor for GREEN, WALK or YELLOW indications on with the RED indication of the channel.

Manual reset shall be required following a conflict or sequence failure, or absence of RED, to place signals in normal operation. Return to normal operation shall be automatic after a power supply fault or power outage, following a preset period of flashing operation. Flashing operation shall not be returned to normal operation if a conflict has been detected prior to a power interruption.

A cabinet interlock shall be provided indicating the presence of the monitor and causing a transfer to flashing operation if the monitor is disconnected. Monitor shall include an LCD readout display with the minimum indicators required as follows:

1. Triggering of the conflict monitoring, RED monitoring, sequence monitoring, +24 V monitor portion #1, +24 V monitor portion #2, and controller voltage monitor;
2. One (1) indicator per channel which displays an active GREEN, YELLOW or WALK input; This channel indicator shall latch with the triggering of the conflict monitor;
3. A RED Failure. The channel indicator(s) in fault shall illuminate;
4. A Sequence Failure. The channel indicator(s) in fault shall illuminate;
5. Watch Dog Monitor. Triggering of watch dog monitor failure;
6. GREEN or WALK vs. YELLOW. Triggering of GREEN or WALK vs. YELLOW failure;
7. GREEN, WALK or YELLOW vs. RED. Triggering of GREEN, WALK or YELLOW vs. RED failure.

Type of monitor to be furnished shall be as shown in Table 650.60-I.

**TABLE 650.60-I
REQUIRED MONITOR TYPES**

Cabinet Type	Monitor Type
4 phase single ring	NEMA Plus 6 Channel
8 phase dual ring	NEMA Plus 12 Channel

650.70 REMOVE/RESETT SIGNAL CONTROLLERS AND CABINETS

When removing and resetting of signal controllers or controller cabinets is called for, materials for new foundations shall be as specified in *Section 620 - Foundations Installations*. Anchor bolts for resetting controller cabinets shall be new. The anchor bolts shall be either fabricated from high strength steel bars with a guaranteed minimum yield strength of 55,000 psi or steel meeting the requirements of AASHTO M 314.

650.80 CONSTRUCTION METHODS

When new traffic actuated controllers and controller cabinets are called for in the contract, the Contractor shall provide controllers and cabinets made by the same manufacturer.

Traffic signal controller cabinets shall be installed on concrete bases at the location shown in the contract or as directed by the Project Manager. The cabinet door shall face away from the street unless otherwise specified in the contract. Upon installation of a ground mounted controller cabinet, the necessary grout or caulking shall be placed between cabinet and concrete base to provide a weather resistant, dust tight installation. No conduit entry shall be made into the side of the cabinet.

A. Testing. The Contractor shall have the controllers and cabinets, and any specified auxiliary equipment transported to the Traffic Services Signal Laboratory in Santa Fe with appropriate written documentation including project identification, signal plan sheets, and transmittal letter, for a maximum thirty (30) day test period prior to the Project Manager's acceptance of compliance with these specifications.

The controller and cabinet furnished at this time shall be capable of operation with all load outputs and shall be complete in accordance with the contract, including auxiliary equipment.

The controller may be subjected to inspection and testing as follows:

1. Visual inspection of compliance with contract requirements, arrangement of equipment, specified markings, and workmanship.
2. Operational Testing including: **a.** Specified phasing; **b.** Various timings; **c.** Indicators; **d.** Pedestrian phasing; **e.** Auxiliary functions and interconnects; **f.** Flash mode; **g.** All possible conflicts for fail safe; **h.** Preemption interruption with every function and phase, when applicable; **I.** Load switches at 1800 watts; **j.** Interrupted power test; and **k.** Timings and operation at input voltage of 105 and 130 VAC.
3. Ambient temperature of 160 degrees Fahrenheit plus/minus 5 degrees Fahrenheit for a maximum period of fourteen (14) days.

The controller will be deemed to have failed to comply with these specifications if, as a result of the previously listed tests, its operation or component parts are affected in any manner. In the event of a component failure all testing will be stopped, and the Contractor will be so notified. It will then be the Contractor's responsibility to provide for the disposition or repair of the controller. The Contractor may submit new or resubmit the repaired equipment for testing, and the Project Manager will determine the length of this new test period up to thirty (30) days.

Upon notification of completion of the lab test and acceptance, the Contractor shall transport the controller and cabinet from Santa Fe to the project site.

In addition to the lab test, final acceptance of all controllers and cabinets shall occur as specified in 605.40-B Operational Tests.

650.90 TURN ON

The turn on of all controllers and auxiliary equipment after installation shall be made only after the entire signal system has been inspected and approved by the Project Manager. The Contractor shall give the Project Manager as well as Personnel from the City's Traffic Operations Department at least five (5) working days advanced written notice of the anticipated turn-on time so that representatives can be present at the turn-on and shall conduct a prepared school for special control equipment.

The Contractor shall remove conflicting traffic control signing after turn-on, as directed by the Project Manager.

651.10 MODIFICATIONS

Modifications and addition of equipment to an existing cabinet shall be made by a qualified signal manufacturer's representative.

Cabinet wiring diagrams will be available at the Traffic Services Signal Laboratory in Santa Fe. The proposed modifications to these wiring diagrams shall be returned and approved by the Project Manager

before any cabinet modification work is started.

All work shall have been inspected by personnel of the signal lab or its delegated representative(s) before the system is re-energized.

651.20 REMOVING/ RESETTING OF SIGNAL CONTROLLER AND CABINET

When removing and resetting of signal controller is called for, the Contractor shall disconnect the existing controller from the existing controller cabinet, remove the controller, relocate to the location shown in the contract, and reinstall the controller in a new or used controller cabinet.

The Contractor shall first construct new foundation at the location shown in the contract. The Contractor shall then remove existing cabinet and relocate the signal controller cabinet to the new foundations with new anchor bolts. All field wiring including loop lead-in cables, power, pedestrian push-buttons, signals, and signal controllers, shall be reconnected to provide a complete and operational signal.

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SECTION 655

LUMINAIRES

655.10 DESCRIPTION

This work shall consist of furnishing and installing luminaries on standards, bridge structures, or sign supports in compliance with the specifications and the details shown in the contract. Lamps, ballasts, necessary mounting hardware, and specified wiring shall be included in this work.

655.20 ROADWAY LUMINAIRE

Roadway luminaries shall be horizontal-burning cobra type with a two (2) inch slipfitter on the house side for mounting on a Type V standard. The lamp type (metal halide, or high pressure sodium), lamp wattage, and line voltage shall be as specified in the contract. The required ballasts shall be an integral part of the luminaire and shall be pre-wired to the lamp socket (may use quick disconnect plugs), requiring only connection to the power supply terminal block (screw type). Terminal block shall be polycarbonate type material. The light distribution shall be ANSI/IES M-S-II. Photometric data in IES format shall be submitted to the Project Manager for approval.

- A. Glassware. Glassware shall be of the refractor type, unless otherwise specified in the contract as a cutoff type, with inner and outer prisms for horizontal light control. Refractors shall be Borosilicate glass. When the contract calls for a cutoff type light distribution, the luminaire shall utilize a shielded optical system that incorporates a specially designed reflector and a heat and impact resistant flatglass lens.
- B. Reflector & Socket. The reflector shall be anodized aluminum, ALZAK, ALGLAS or approved equal treatment. The socket shall be of a high grade porcelain with both axial and vertical adjustment.
- C. Photocell Controller. An individual photocell controller on the top of the housing, mounted inside or outside, shall be provided when specified. The photo control receptacle shall be polycarbonate material.
- D. Mounting Requirements. The refractor shall be mounted in a door frame assembly which shall be hinged to the luminaire at the house side and fastened at the street side by means of an automatic latch. The reflector and lamp socket shall be secured to the upper housing. The refractor and door frame assembly shall be forced upward at the street side by spring pressure against a gasket seat when in the closed and latched position.

The ballast shall be an easily removable power pack connected by a quick disconnect plug. The ballast shall be accessed through a separate rear door not disturbing the sealed optical system, or through a single door, also accessing the optical system, if the ballast and other electrical components are removable with only the use of a flat blade screwdriver. The slipfitter shall provide clamping on 1 inch or 2 inch pipe bracket without removal of the clamping device. It shall also permit leveling of the luminaire on the horizontal plus or minus three degrees.

All gaskets shall be composed of a breathing material capable of filtering as well as sealing the fixture, and material capable of withstanding the temperature involved and shall be securely held in place. The housing and refractor ring shall be of die-cast aluminum. The latch and exposed hinge parts shall be manufactured from noncorrosive material.

When mounted on bridge deck, pole shall be mounted on vibration dampening pad and the fixture shall have lamp stabilizer to reduce the potential for damage to the fixtures from vibration. The fixture shall be certified to withstand a 3G vibration test.

655.30 SIGN LUMINAIRE

Sign luminaries shall be metal halide luminaries designed to illuminate a retroreflecting sign face from a horizontal position below the sign. The sign luminaire shall be mounted by means of a 1 inch pipe slip fitter. The support bracket shall be fabricated of 1 inch Schedule 40 steel pipe securely welded to an inch steel mounting plate, designed to bolt directly to supports on the back of the sign.

The ballast shall be contained in a weatherproof capsule designated to be bolted to the mounting plate and wired to the luminaire through the support pipe. A ballast internal to the fixture may be used when the additional weight does not require a redesign of the detailed support. When the fixture is specified to be mounted on the catwalk of the sign structure it shall be mounted with a three (3) or four (4) bolt pattern. The luminaire support and mounting details shall conform to details in the contract.

The luminaire shall be designed to provide a maximum uniformity gradient of two to one (2:1) (ratio of illumination of any one (1) square foot of sign face to any one (1) adjacent square foot). The luminaire shall consist of a die cast aluminum ballast housing, anodized aluminum reflector, tempered glass lens and hinged door on reflector.

655.40 BALLASTS

Ballasts for high intensity discharge lamps shall be for the primary current and types of lamps specified. Unless otherwise specified, the ballast shall be an integral part of the luminaire. All ballasts shall be designed to meet ANSI Specifications.

- A. Metal Halide Lamp Ballast. Ballasts for metal halide lamps shall be of the constant wattage auto regulated type with a voltage input range of plus or minus ten percent (10%) and a transient impulse level of 7.5 K. The ballast shall be of the high power factor design and have a lamp wattage regulation of plus or minus ten percent. (10%).
- B. High Pressure Sodium Ballasts. Ballasts for 250 W and 400 W high pressure sodium lamps shall have isolated primary and secondary lamp circuit windings. They shall have a transient impulse level of ten (10) K., voltage input range of plus or minus ten percent (10%) and ballast loss of no more than twenty percent (20%). If the contract details specify an integrated circuit design ballast, it shall have isolated primary and secondary lamp circuit windings and transient impulse level of ten (10) K. Ballasts for 1000 W high pressure sodium lamps shall be of the constant wattage auto regulation type. They shall have a transient impulse level of 7.5 kV, voltage input range of plus or minus ten percent (10%) and a ballast wattage loss of no more than ten percent (10%).

655.50 LAMPS

High intensity discharge (HID) lamps for luminaries shall conform to the requirements shown in Table 655.50-A.

**TABLE 655.50-A
HIGH INTENSITY DISCHARGE LAMP REQUIREMENTS**

Description Watts (ANSI Spec.)	Minimum Initial Lumens ¹	Minimum Rate Life (Hours) ²	Use
Metal Halide			
175 Coated (M57)	15,000 (h)	7,500	Sign Lighting
400 Clear (M59)	32,000 (h)	20,000	Roadway

¹ Vertical or horizontal bulb position indicated where different.

² Base on ten (10) hours per start. When less than 24,000 hrs., it is median value of life expectancy. When 24,000 or greater, sixty seven percent (67%) of lamps shall be expected to be burning at 24,000 hrs.

655.60 CONSTRUCTION METHODS

The Contractor shall properly align and level all luminaries in accordance with the manufacturer's and design requirements. The installation of luminaries shall include two (2) single conductors, #10 or as specified, to the standard pole base or nearest splice point into main distribution feed.

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SECTION 660

METAL AND CONCRETE WALL BARRIER

660.10 DESCRIPTION

This work shall consist of the construction of metal barrier and anchorages and concrete wall barrier (CWB) in compliance with these specifications and the lines, grades, and dimensions shown in the contract.

When called for, this work shall also consist of removing existing barrier and reinstalling the barrier at new locations.

The construction of the various types of metal barrier and anchorages shall include the assembly and erection of all components and materials.

The construction of the various types of CWB shall include foundation preparation, component parts, and materials completed at the location shown in the contract.

660.20 MATERIALS

The types of metal barrier are designated as follows:

- W-Beam Metal Barrier & W-Beam Weathering Metal Barrier
- Thrie Beam Metal Barrier & Thrie Beam Weathering Metal Barrier
- Post & Cable Barrier

The types of CWB are designated as follows:

- Slip formed CWB
- Cast in place CWB
- Precast CWB

- A. Rail Elements. W-Beam and thrie beam rail elements shall consist of a corrugated beam conforming to the requirements of AASHTO M 180, Type I, Class A. Steel rail elements may be galvanized before or after fabrication, in accordance with the requirements of AASHTO M 180. The wire rope or wire cable and required fittings shall conform to the requirements of AASHTO M 30 for the specified diameter and strength class.

W-Beam and thrie beam materials for corrosion resistant "Weathering" metal barrier shall comply with the requirements of AASHTO M 180, Type IV Class A and ASTM A 606-90 Type IV having a corrosion resistance of at least four (4) times that of plain carbon steel.

- B. Fasteners. Fasteners include bolts, nuts, and washers. Unless otherwise specified, all fasteners shall be galvanized in accordance with the current requirements of AASHTO M 111 or ASTM A 153, whichever may apply. All galvanizing shall be done after fabrication.

Bolts shall conform to the requirements of ASTM A 307 and nuts to the requirements of ASTM A 563, Grade A or better.

Fasteners for weathering metal barrier shall conform to the requirements of AASHTO M 180 for Type IV beams.

- C. Posts. Posts include post, blocks, support angles, and support plates. Wood posts and wood blocks shall be southern yellow pine, western larch, ponderosa pine, douglas fir, or lodgepole pine and shall be either rough sawn (unplaned) or S4S with nominal dimensions indicated and with a stress grade of at least 1200 psi. Posts shall be straight and free from all defects, and shall not vary more than one (1) inch from a straight line connecting both ends.

The size tolerance of rough sawn blocks in the direction of the bolt holes shall be within $\pm 1/4$ inch of specified dimensions. Only one (1) combination of post and block shall be used for any one (1) continuous length of barrier.

The cutting, framing, and boring shall be done before the timber receives a preservative treatment. Wood posts and blocks shall be pressure treated with petroleum pentachlorophenol consisting of not more than ninety five (95) parts by weight of petroleum oil and not less than five (5) parts by weight of pentachlorophenol, with ammoniacal copper arsenite, or with chromated copper arsenate. The empty cell process shall be used for petroleum-pentachlorophenol treatment. The amount of pentachlorophenol retained shall be at least 0.3 pounds of dry salt per cubic foot of wood. Treatment with ammoniacal copper arsenite or chromated copper arsenate shall be done in accordance with the requirements of the American Wood Preservers Association (AWPA) C14. Wood preservatives shall conform to the requirements of AASHTO M 133.

- D. Structural Shape Post & Blocks. Structural shape posts and blocks shall conform to ASTM A 36 and shall be galvanized in accordance with ASTM A 123. No punching, drilling, or cutting will be permitted after galvanizing.
- E. Bent Plate Post & Block. Bent plate post and block (steel) shall conform to the requirements of ASTM A 570 with mechanical properties equal to ASTM A 36 and shall be galvanized in accordance with ASTM A 123. No punching, drilling, or cutting will be permitted after galvanizing.
- F. Concrete Wall Barrier. Concrete shall be Class A conforming to the provisions of Section 510 -- Portland Cement Concrete. Reinforcing steel shall conform to the requirements of Subsection 540 -- Steel Reinforcement. Preformed bituminous joint filler shall comply with the requirements of AASHTO M 123. Penetrating water repellent shall comply with the requirements of Section 532 -- Penetrating Water Repellent Treatment.

660.30 METAL BARRIER CONSTRUCTION REQUIREMENTS

During construction, the Contractor shall effect all necessary precautions to prevent all exposed metal or concrete barrier ends from becoming a hazard to the traveling public. The method proposed by the Contractor to effect these precautions must be approved by the Project Manager prior to implementation.

- A. Metal Barrier Installation. Steel parts stored in transit, in open cars, trucks, or outside in yards or at job sites, shall be positioned to allow free drainage and air circulation. All fabricated steel parts shall be handled with care to avoid gouges, scratches, and dents. The steel shall be kept clean of all foreign material, such as paint, grease oil, chalk marks, crayon marks, concrete spatter, or other deleterious substances. When weathering metal barrier is called for, natural oxidation of steel will not be considered foreign material. Coating, galvanizing, blast cleaning, or picking of weathering metal barrier to remove mill scale will not be required. All bolts except adjustment bolts shall be drawn tight. Bolts shall be of sufficient length to extend beyond the nuts.

A 12" x 18" 60 mil yellow reflective plastic tape shall be affixed to all Type C anchor box gloves.

- B. Posts. Posts shall be set plumb, in hand dug or mechanically made holes, or by driving. If upward vertical adjustment of posts is necessary, the post shall be removed and reinstalled. The method of driving shall be such as to avoid battering or distorting of posts. Driving of steel posts will be permitted through the bituminous surfacing. Driving of wooden posts will not be permitted through bituminous surfacing unless guide holes are precut or drilled through the bituminous material. In all cases, drilling and driving of posts shall be performed in a manner which does not cause bulging or distressing or other disturbance of the bituminous surface.

Post holes shall be backfilled with acceptable material placed in layers and shall be thoroughly compacted. The bituminous surfacing material shall be replaced with approved bituminous surfacing material and shall be thoroughly compacted. Concrete may be used in lieu of bituminous surfacing material if the hot mix plant has been removed or is no longer operational, at no additional cost to the Department and when approved by the Project Manager.

Should bulging or other distress of the bituminous surfacing occur when driving steel posts, these posts shall be removed and reinstalled utilizing guide holes drilled through the bituminous surfacing. The guide holes shall have a maximum diameter as required in accordance with Table 606.30-A.

**TABLE 606.30-A
REQUIRED GUIDE HOLE DIAMETER**

Post Type	Maximum Diameter
Round Wood	Diameter of Post
Square Wood	Dimension of Side
Steel Shape	Dimension of Least Side

After the guide holes have been precut or drilled, if bulging or other distress of the bituminous surfacing occurs during the driving of posts or if the post is prevented from being driven to the designated depth, the driving shall cease. This post(s) shall then be removed and the guide holes shall be extended as necessary.

- C. Metal Rail Installation. Rail elements shall be erected in a manner resulting in a smooth, continuous installation. Rails shall be overlapped in the same direction as the traffic flow of the nearest lane. Only drilling or cutting necessary for special connections and for sampling will be permitted in the field.

Rails to be erected on a radius of 150 feet or less shall be shop curved to the appropriate curvature of the installation.

- D. Removing & Reinstalling Metal Barrier. When called for, existing metal barrier shall be removed and reinstalled as shown in the contract. Salvaged metal barrier shall be reinstalled in accordance with all the applicable requirements of these specifications. Reuse of existing components of the metal barrier will be subject to the approval of the Project Manager. Where new materials are required to replace existing materials unsuitable for reuse or to comply with the details shown in the contract, the new materials shall comply with these specifications.
- E. Repair of Damaged Coating. Where the galvanized of metal barrier or appurtenances has been damaged, the coating shall be repaired by galvanizing or by coating with two (2) coats of zinc dust-zinc oxide paint conforming to Federal Specifications TT-P-641 or ML-P-21035.

660.40 CONCRETE WALL BARRIER CONSTRUCTION REQUIREMENTS

Permanent CWB may be cast in place, precast, or slip formed. All precast CWB shall be of the same length and design, and intermixing will not be allowed. The Contractor shall be responsible for damage to precast CWB occurring in any phase of the work. The Project Manager will be the sole judge as to the severity of the damage and may either reject or accept the damaged precast CWB. In the event that a precast CWB is rejected because of damage, the Contractor shall replace or repair the damaged precast CWB at no additional cost to the City.

Temporary CWB shall furnished by the Contractor and set at the locations shown in the contract in accordance with the requirements for traffic control. The Contractor shall provide all loading, hauling and unloading necessary for use at designated sites. When resetting of CWB is called for, the Contractor shall reset the required CWB during construction at the locations shown in the contract in accordance with the requirements for traffic control. After completion of the project the Contractor shall effect removal and shall load, haul, unload and stockpile the CWB at locations designated in the contract, as approved by the Project Manager.

- A. Concrete Wall Barrier Fabrication. All fabrication of CWB shall be accomplished in accordance with the applicable provisions of Section 500- Portland Cement Concrete and Section 505- Concrete Placing and Finishing. Precast CWB shall be constructed in ten (10) foot units true to the lines and grades shown in the contract.

Permanent CWB shall be constructed true to line and grade, and the top of the completed barrier shall not deviate more than the CWB shall be Class 2, Rubbed Surface Finish, or Special Surface Finish, complying with the requirements of Subsection 511.38 Finishing., and shall be smooth, dense, and free from air bubble pockets, pits, depressions, honeycombs, and other irregularities.

Sandblasting, if required by the manufacturer, shall be accomplished such that mortar used in the surface finish is not displaced from the bubble pockets, pits, depressions, and honeycombs.

- B. CWB Joint Treatment. When traverse weakened plane joints are sawed, they shall be done at such time that no raveling will occur and when the concrete has hardened sufficiently so that no crumbling or shape deformation will occur when the forms are removed. Control joints shall be sawed at intervals of ten (10) feet. After completion of sawing operations, the sawed area shall be thoroughly cleaned of all debris. A construction joint shall be made at the end of each day of permanent placement operations and at any point where concrete placement is interrupted for thirty (30) minutes or more.
- C. State Furnished Concrete Wall Barrier. When the contract calls for State furnished CWB to be used, the Contractor will not be required to furnish the CWB but shall load, haul and unload State furnished CWB from origins to destinations shown in the contract. Unless otherwise specified in the contract, State furnished CWB shall remain the property of the Department upon completion of the project. State furnished CWB shall be hauled and stockpiled as shown in the contract or as determined by the Project Manager. When State furnished CWB is provided, the Contractor shall provide connection pins for CWB assembly if none are included with the CWB. All other applicable requirements of Subsection 660.40 A.) Concrete Wall Barrier Installation, shall apply.

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SECTION 700

METRIC CONVERSION

700.00 BACKGROUND

The Federal Highway Administration (FHWA) has mandated that all projects to be built with Federal funds use Metric Plans and Specifications. This measure has extended through the New Mexico State Highway and Transportation Department (NMSHTD) to the Local level. The City of Las Cruces has adopted guidelines sanctioned by the FHWA and NMSHTD. Section 600 of this document has been prepared as a guide to comply with these directives. **All construction plans submitted to the City of Las Cruces after September 1996 shall use the metric system of measurement.**

700.01 INTRODUCTION

It is important that drawings and specifications be made exclusively metric. It is of secondary importance if measurements are hard or soft metric as defined below. It would follow that when documents contain SI measurements only, the reader will learn metric in order to execute or understand the work.

The natural tendency is for people to use dual dimensioning (both English and Metric) units during the conversion process. This should not be done, except on documents such as Right-of-Way or Environmental where there is a direct public involvement and approval has been obtained from the Director of Development Services Division of the City of Las Cruces. This policy will help prevent errors and will reduce the potential for confusion.

During the metric conversion process, the reader will encounter the use of the terms "Soft Conversion" and "Hard Conversion." Soft Conversion or Soft Metric means that the product or dimension requires no physical change. One would merely compute (or measure) the dimension and state its metric equivalent. Hard Conversion or Hard Metric means that the product or dimension requires physical change, ie. adjust the lane width to agree with a user accepted rounded number.

This section has been prepared to aide in the conversion process. Many areas will be affected and have been outlined in this following paragraphs.

700.02 STATIONING

- A. 1 Sta. = 1,000 meters (m) = 1 kilometers (km)
Example: Sta. 5+123.500 (This will provide a visible difference between the English and metric stations, two versus three digits after the plus sign, and will avoid confusion in the future r when reviewing or using plans designed in imperial units.)
- B. Stations should increase from West to East and from South to North.
- C. Alignment stakes and cross-sections will normally be taken at 20 meter intervals.
- D. Label all elevations in meters and decimals of a meter. **Example: Elev. = 182.880 m**

700.03 SURVEYING

- A. Use 1 mm accuracy for all measurements except:
 - a. natural ground elevations - use nearest 10 mm
 - b. elevations on existing pavement surfaces - use nearest 5 mm
- B. Angles will continue to be measured in degrees/minutes/seconds.
- C. All recorded deed measurements shall be shown in parenthesis in the units recorded, such as feet, rods, or chains.
- D. Distance and area measurements on Right-of-Way documents should be shown in dual units with the metric units shown first, followed by the English equivalent in parenthesis. This practice will be essential for property owners to understand the value of appraisals and other negotiations related to the acquisition of Right-of-Way. **Example: 63.17 m (207.25 ft.)**
- E. Dual units are only permitted on Right-of-Way plans and other documents that may be used in

negotiations with property owners. Plans in general shall not use dual dimensioning.

700.04 ANGLES AND HORIZONTAL CURVES

- A. Angular measurement will continue to be expressed in Degrees (°), Minutes ('), and Seconds (").
- B. Radius definition of curves, with the radius expressed in meters, will be used rather than Degree of Curve as we currently use. For example, a 3 degree horizontal curve on new alignment (Radius=1909.86 ft. or 582.126 m) should be referred to as a 580.000 m radius curve. Metric radius on office location horizontal curves should always be expressed in multiples of 5 m increments.
- C. On the other hand, alignments which incorporate a previously defined horizontal curve should continue to express the radius to the closes 0.001 m. If the 3 degree curve noted above is a re-creation of a previously established curve, it should be assigned a 582.126 m radius.
- D. Listed below are three cases defining horizontal curves. In all three cases the curve starts at P.C. Station 300+59.41 (English), equivalent to P.C. Station 9+162.126 (metric).

Case A: Normal English curve definition.

Case B: Metric definition assuming that Case A curve data defined the roadway centerline from a previous survey and is to be retained. All curve data is a direct conversion from English to metric.

Case C: Metric definition of an office location starting at P.C. Station 9+162.126 having approx. the same curvature as the Case A curve. Note that the radius is given in a 5 m increment.

Case A	Case B	Case C
P.I.Sta. = 302+68.57	P.I.Sta. = 9+225.897	P.I.Sta. = 9+225.646
$\Delta = 12^{\circ}30'$	$\Delta = 12^{\circ}30'$	$\Delta = 12^{\circ}30'$
$D = 3^{\circ}00'$	$R = 582.126 \text{ m}$	$R = 580.000 \text{ m}$
$T = 209.16'$	$T = 63.753 \text{ m}$	$T = 63.520 \text{ m}$
$L = 416.67'$	$L = 127.000 \text{ m}$	$L = 126.536 \text{ m}$

- E. This information is based on the Arc definition for Degree of Curve (D) and uses the following formulas for Degree, Length and Tangent of Curve:

$$D = \frac{1746.379}{R} ; (R \text{ in meters}) \quad L = (30.48006) \Delta / D$$

and $T = R \tan (\Delta / 2) ; (R, L \text{ and } T \text{ in meters})$

700.05 SURVEY PLOTTING ACCURACY

- A. As a frame of reference, distances expressed in metric units will have the following accuracy in English units:
 1. Closest 0.1 meters will be within 2" of the true distance
 2. Closest 0.01 meters will be within 3/16" of the true distance
- B. Survey distances and elevations transferred to plan sheets should be shown as follows:
 1. Horizontal alignment data (curve information, equations, reference point tie-ins, etc.) and Benchmark elevations should be shown to the closest 0.001 m.
 2. Roadway elevations, used for pavement tie-ins and vertical clearance computations, should be shown to the closest 0.01 m.
 3. All horizontal pluses, offsets, physical feature dimensions and locations, etc. should be shown to the closest 0.01 m.

700.06 PROPOSED FEATURES ON ROADWAY PLANS

- A. The location of all proposed features should be given in meters or fractional parts of meters to the following accuracy:
 1. All proposed horizontal alignment data should be given to an accuracy of 0.001 meters.

2. Metric curve radii should be in 5 meter increments.
3. Vertical Profile Alignment Data should be shown with V.P.I Stations at even 10 m stations, V.C. Lengths in 20 m increments, and V.P.I. Elevations given to 0.001 m accuracy, where practical.
4. All other vertical elevations (break in ditch grades, pipe invert elevations, etc.) should be shown to the closest 0.01 meters.
5. The location of all proposed features should be shown to the closest one meter, where practical, and never closer than 0.01 meter. The following increments are recommended:
 - Drive locations Closest 1.0 meters
 - Culvert locations Closest 1.0 meters
 - Horizontal ditch grade breaks Closest 1.0 meters
 - Guardrail limits Closest 0.1 meters

700.07 PHOTOGRAMMETRY

Contour Intervals:

Index Contours	Intermediate Contours
1 meter	250 mm
2 meter	500 mm
5 meter	1 m

700.08 DRAFTING STANDARDS

1. Use recommended dimensionless metric scales as follows:

METRIC RATIO SCALES (RELATED TO IMPERIAL SCALES)

Imperial Scales	Metric equivalent	Metric Scale
1"=2'	1:24 (1 cm = 0.2400 m)	1:20 (1 cm = 0.2 m)
1"=4'	1:48 (1 cm = 0.4800 m)	1:50 (1 cm = 0.5 m)
1"=10'	1:120 (1 cm = 1.2 m)	1:100 (1 cm = 1 m)
1"=20'	1:240 (1 cm = 2.4 m)	1:200 (1 cm = 2 m)
1"=50'	1:600 (1 cm = 6 m)	1:500 (1 cm = 5 m)
1"=100'	1:1200 (1 cm = 12 m)	1:1000 (1 cm = 10 m)
1"=200'	1:2400 (1 cm = 24 m)	1:2000 (1 cm = 20 m)
1"=300'	1:3600 (1 cm = 36 m)	
1"=400'	1:4800 (1 cm = 48 m)	1:5000 (1 cm = 50 m)
1"=600'	1:7200 (1 cm = 72 m)	
1"=800'	1:9600 (1 cm = 240 m)	1:10000 (1 cm = 100 m)
1"=2000'	1:24000 (1 cm = 240 m)	1:24000 (1 cm = 240 m)*

* Soft conversion until USGS maps are converted to metric

Architectural Scales	Recommended Dimensionless Metric Scales
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3" = 1'	1:5
1 1/2" = 1'; 1" = 1'	1:10
3/4" = 1'; 1/2" = 1'	1:20
1/4" = 1'	1:50
1/8" = 1'	1:100
1/16" = 1'	1:200
1/32" = 1'	1:500

2. Use text size as follows:

Leroy	Metric Equivalent	Metric Text Size
80	2.032 mm	2.0 mm
100	2.540 mm	2.5 mm
120	3.048 mm	3.0 mm
140	3.556 mm	3.5 mm
175	4.445 mm	4.5 mm
200	5.080 mm	5.0 mm
240	6.096 mm	6.0 mm
290	7.366 mm	7.5 mm
350	8.890 mm	9.0 mm

700.09 GEOMETRIC DESIGN

1. Curve radius, R, shall be measured in meters for horizontal curvature.
2. Express pavement cross-slopes as a ratio or a percent. **Ex.: 0.020 m/m or 2.0%**
3. Continue to express vertical gradients as percent (rise/run) where (1/1 = 100%). For slopes less than 45°, the vertical component should be unitary (ie. 3:1). For slopes over 45°, the horizontal component should be unitary (ie. 1:5)
4. Continue to express side slopes as a dimensionless ratio of H:V. **Example: 4:1**
5. The following selected metric values have been extracted from Interim Selected Metric Values for Geometric Design, An addendum to AASHTO'S A Policy on Geometric Design of Highways and Streets, 1990. These are presented here for quick reference. For a more complete list, refer to AASHTO publications.
6. Many of the values used in design do not convert to a nice round number in the metric system. Consequently these values are hard converted to an easy to use number, ie. a design speed of 70 mph is equal to 113 km/h. A value of 110 km/h or 120 km/h should be used.
 - a. SPEED

Design Speed km/h	Running Speed km/h
----------------------	-----------------------

30	(18.64 mph)	30
40	(24.85 mph)	40
50	(31.07 mph)	47
60	(37.28 mph)	55
70	(43.50 mph)	63
80	(49.71 mph)	70
90	(55.92 mph)	77
100	(62.14 mph)	85
110	(68.35 mph)	91
120	(74.56 mph)	98

b. WIDTH

Driving Lanes equivalents		Shoulders equivalent	
2.7 m	(8.86 ft)	0.6 m	(1.97 ft)
3.0 m	(9.84 ft)	1.2 m	(3.94 ft)
3.3 m	(10.83 ft)	1.8 m	(5.91 ft)
3.6 m	(11.81 ft)	2.4 m	(7.87 ft)
		3.0 m	(9.84 ft)

c. CLEAR ZONE

Please refer to the Roadside Design Guide for Clear Zone values. The Clear Zone values will have to be soft converted until the appropriate manuals are revised and converted to metric.

d. SIGHT DISTANCE

Stopping Sight Distance		
Eye Height	1,070 mm	(3.51 ft)
Object Height	150 mm	(5.91 in)
Headlight Height	610 mm	(2 ft)
Passing Sight Distance		
Eye Height	1,070 mm	(3.51 ft)
Object Height	1,300 mm	(4.27 ft)

e. HORIZONTAL CURVATURE

Radius definition should be used in lieu of degree of curve. Radius should be expressed in multiples of 5 m increments.

700.10 PLAN & PROFILE SHEETS

A. Recommended Scales:

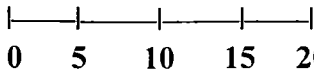
Scale	Plan Coverage
1:200 (1 cm = 2 m)	120 m
1:500 (1 cm = 5 m)	300 m
1:1000 (1 cm = 10 m)	600 m

B. Grid lines for profiles will be at 20 mm intervals.

C. Use same ratio between horizontal and vertical scales as we have used in the English system.

Example: A scale of 1"=100' horizontal and 1"=10' vertical. Thus H:V ratio is 100:10 or 10:1

Then, for metric scale, use 1:1000 horizontally and 1:100 vertically.

- D. Show bar scale next to written scale: **Example:**  0 5 10 15 20 m

700.11_SELECTED MATERIAL DESIGNATIONS

Materials which are specified by size will be designated in metric units. Metric designations for several common materials are included here.

700.12 STEEL REINFORCING (REBAR)

Specification reference - AASHTO M-31M

Bar Designation No.	Nominal Mass, kg/m	Diameter mm	Cross-sectional	
			Area mm ²	Perimeter mm
10	0.785	11.3	100	35.5
15	1.570	16.0	200	50.3
20	2.355	19.5	300	61.3
25	3.925	25.2	500	79.2
30	5.495	29.9	700	93.9
35	7.850	35.7	1000	112.2
45	11.775	43.7	1500	137.3
55	19.625	56.4	2500	177.2

700.13 STRUCTURAL STEEL

- A. Specification reference - AASHTO M-160M and ASTM A6/A6M
- B. Reference is hereby made to the listed specifications for the size designations as they are to numerous to include in these guidelines.

700.14 CORRUGATED STEEL PIPE

Specification reference - AASHTO M-36M

Size Designations

Nominal Inside Diameter		Nominal Inside Diameter		Nominal Inside Diameter	
in.	mm	in.	mm	in.	mm
4	100	30	800	84	2200
6	150	36	900	90	---
8	200	42	1000	96	2400
10	250	48	1200	102	---
12	300	54	1400	108	2700
15	400	60	---	114	---
18	450	--	1600	120	3000
21	500	66	---	---	3300
24	600	72	1800	---	3600
--	700	78	2000		

700.15 REINFORCED CONCRETE PIPE

Specification reference - AASHTO M-170M

Size Designations

Nominal inside Diameter		Nominal inside Diameter		Nominal inside Diameter	
in.	mm	in.	mm	in.	mm
60	1500	90	2250	120	3000
66	1650	96	2400	126	3150
72	1800	102	2550	132	3300
78	1950	108	2700	138	3450
84	2100	114	2850	144	3600

700.16 WIRE CLOTH SIEVE SIZE DESIGNATIONS

The table below is from information contained in AASHTO M92 and ASTM E11 "Wire Cloth Sieve for Testing Purposes", and shows Standard (Metric) and Alternative (U.S. Customary) sieve size designations. As shown, metric size designations are given in mm or μm . (1,000 μm = 1 millimeter)

Standard	Alternate	Standard	Alternate	Standard	Alternate	Standard	Alternate
125 mm	5 in.	13.2 mm	0.530 in.	1.70 mm	No. 12	150 μm	No. 100
100 mm	4 in.	12.5 mm	1/2 in.	1.40 mm	No. 14	125 μm	No. 120
90 mm	3-1/2 in.	11.2 mm	7/16 in.	1.18 mm	No. 16	106 μm	No. 140
75 mm	3 in.	9.5 mm	3/8 in.	710 μm	No. 25	90 μm	No. 170
50 mm	2 in.	8.0 mm	5/16 in.	600 μm	No. 30	75 μm	No. 200
45 mm	1-3/4 in.	6.7 mm	0.265 in.	500 μm	No. 35	63 μm	No. 230
37.5 mm	1-1/2 in.	6.3 mm	1/4 in.	425 μm	No. 40	53 μm	No. 270
31.5 mm	1-1/4 in.	5.6 mm	No. 3-1/2	355 μm	No. 45	45 μm	No. 325
26.5 mm	1.06 in.	4.75 mm	No. 4	300 μm	No. 50	38 μm	No. 400
25.0 mm	1 in.	4.00 mm	No. 5	250 μm	No. 60	32 μm	No. 450
22.4 mm	7/8 in.	3.35 mm	No. 6	212 μm	No. 70	25 μm	No. 500
19.0 mm	3/4 in.	2.80 mm	No. 7	180 μm	No. 80	20 μm	No. 635
16.0 mm	5/8 in.	2.36 mm	No. 8				

700.17 BASE UNITS

There are seven base metric units of measurement. These are meter, kilogram, second, ampere, kelvin, mole and candela. The base units which are used in highway design and construction are listed below.

Quantity	Unit	Symbol
length	meter	m
mass*	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin	K
luminous intensity	candela	cd

Please note Upper vs: Lower-case symbols

* "Weight" in common practice often is used interchangeably with mass"

700.18 DECIMAL PREFIXES

Only two decimal prefixes are commonly used with the base units in design and construction. These are as shown in the following table:

Prefix	Symbol	Order of Magnitude	Expression
kilo	k	10^3	1000 (one thousand)
milli	m	10^{-3}	0.001 (one thousandth)

The prefixes mega (M) for one million (10^6), giga (G) for one billion (10^9), micro (μ) for one millionth (10^{-6}), and nano (n) for one billionth (10^{-9}) are used in some engineering calculations.

Decimal prefixes to the tertiary power of 10 are preferred (meaning in multiples of 3 i.e., 10^3 , 10^6 , etc.) The prefixes deci (d) for one tenth (10^{-1}), centi (c) for one hundredth (10^{-2}), deca (da) for ten (10^1), and hecto (h) for one hundred (10^2) have limited application in design and construction.

700.19 TEMPERATURE

Celsius temperature ($^{\circ}\text{C}$) is more commonly used than kelvin (K), but both have the same temperature gradients. Celsius temperature is simply 273.15 degrees warmer than kelvin. Kelvin begins at absolute zero. For instance, water freezes at 273.15 K and at 0°C ; it boils at 373.15 K and at 100°C . To move between Celsius and kelvin, add or subtract 273.15. Please note the use of the symbol, ($^{\circ}$), for degrees Celsius. The symbol, ($^{\circ}$), is not used for degrees K. The following formulas can be used for conversation from $^{\circ}\text{F}$ to $^{\circ}\text{C}$ and vice versa:

$$^{\circ}\text{C} = 5/9(^{\circ}\text{F} - 32) \quad ^{\circ}\text{F} = 9/5(^{\circ}\text{C}) + 32$$

700.20 DERIVED UNITS

As shown previously, there are only seven base units in the metric system. There are, however, many derived units which are used in the metric system. Some of the derived units which are used in design are units such as (t) for metric ton; square meter for area; and cubic meters per second for flow rate.

700.21 PLANE AND SOLID ANGLES

The radian (rad) and steradian (sr) denote plane and solid angles. They are used in lighting work and in various engineering calculations. In surveying, the units degree ($^{\circ}$), minute ($'$), and second ($''$) will continue to be used.

700.22 LITER, HECTARE, AND METRIC TON

The liter (L) is the measurement for liquid volume. The hectare (ha) is a metric measurement used to replace the acre. The metric ton (t) is used to denote large loads such as those used in surfacing aggregates. This will replace the "ton". Caution should be exercised when using and computing tonne(s), since the metric tonne is abbreviated (t) and it could easily be confused with the English ton.

700.23 RULES FOR WRITING METRIC SYMBOLS, NAMES, AND NUMBERS

- A. Print unit symbols in upright type and in lower case except for liter (L) or unless the unit name is derived from a proper name.
- B. Print unit names in lower case, even those derived from a proper name.
- C. Print decimal prefixes in lower case for magnitudes 10^3 and lower (that is: k, m, μ , and n) and print the prefixes in upper case for magnitudes 10^6 and higher (that is M and G).
- D. Leave a space between the numeral and the symbol (write 45 kg or 37°C , not 45kg or 37°C).
- E. Do not use a degree mark ($^{\circ}$) with kelvin temperature (write K, not $^{\circ}\text{K}$).
- F. Do not leave a space between a unit symbol and its decimal prefix (write kg, not k g).
- G. Do not use the plural of unit symbols (write 40 kg, not kgs), but do use the plural of written unit names (forty kilograms).
- H. For technical writing, use symbols in conjunction with numerals (the area is 10 m); write out unit names if numerals are not used (carpet is measured in square meters). Numerals may be combined with written unit names in non-technical writing (10 meters).
- I. Indicate the product of twounits in symbolic form by using a dot positioned above the line (kg•m•s).
- J. Do not mix names and symbols (write N•m or newton meter, not N•meter nor newton•m).

- K. Do not use a period after a symbol (write "12 g", not "12 g.") except when it occurs at the end of a sentence.
- M. Always use decimals, not fractions (write 0.75 g, not 3/4 g).
- N. Use a zero before the decimal marker for values less than one (1) (write 0.45 g, not ,45 g).
- O. Commas shall continue to be used to separate digits into groups of three. Spaces will not be used to separate the groups.

700.24 CONVERSION AND ROUNDING

- A. When converting values from miles to kilometers, round off the resultant metric value to the same number of digits as there were in the mile number (11 miles at 1.609 km/mi equals 17.699 km, which rounds off to 18 km. 12.26 miles at 1.609 km/mi equals 19.726 km, which rounds off to 19.73 km, etc.)
- B. Convert mixed inch-pound units (feet and inches, pounds and ounces) to the smaller unit, inch-pound, before converting to metric and rounding off (10 feet, 3 inches = 123 inches; 123 inches x 25.4 mm = 3124.2 mm; round to 3124 mm).
- C. In a "soft" conversion, an English measurement is mathematically converted to its exact (or nearly exact) metric equivalent. With "hard" conversion, a new rounded rationalized metric number is created that is convenient to work with and remember.

700.25 GENERAL CIVIL ENGINEERING

One metric unit is used to measure length, area, and volume in most design and construction work. This unit is: meter (m)

700.26 RULES FOR LINEAR MEASUREMENT (LENGTH)

- A. Use the kilometer for long distances and the millimeter for precision measurements.
- B. Measurements done in millimeter will typically be in whole numbers. Those done in meters will typically have at least one decimal place.
- C. Avoid use of the centimeter.
- D. For survey measurement, use the meter and the kilometer.
- E. Use only the meter and millimeter in building design and architectural construction.

700.27 RULES FOR AREA

- A. The square meter is preferred.
- B. Very large areas may be expressed in square kilometers and very small areas, in square millimeters.
- C. Use the hectare (10,000 square meters) for land and water measurement only.
- D. Avoid use of the square centimeter.
- E. Linear dimensions such as: 40 x 90 mm may be used; if so, indicate width first and height second.

700.28 RULES FOR VOLUME AND FLUID CAPACITY

- A. Cubic meter is preferred for volumes in construction and for measurements such as large storage tanks.
- B. Use liter (L) and milliliter (mL) for fluid capacity (liquid volume). One liter is 1/1000 of a cubic meter or 1000 cubic centimeters.
- C. Since a cubic meter equals one billion cubic millimeters, the cubic decimeter and cubic centimeter may be used in limited applications, because they are multiples of 1000 in volume measurement.

700.29 RULES FOR CIVIL ENGINEERING

- A. Plane angles in surveying (cartography) will continue to be measured in degrees (either decimal degrees or degrees, minutes, and seconds) rather than the metric radian or grads.
- B. Slope is expressed in non-dimensional ratios. The horizontal component is shown first and then the vertical. For instance, a rise of one meter in four meters is expressed as 4:1. The units that are compared should be the same (meters to meters, millimeters to millimeters, etc.). Please note that a

slope measured as a rise of one meter to a run of four meters is equivalent to a slope measured as a rise of one foot to a run of four feet.

700.30 GENERAL CIVIL ENGINEERING CONVERSION FACTORS

To convert from English		To Metric	Multiply by:
Length	mile	km	1.609347
	yard	m	0.9144
	foot	m	0.3048006
	foot	mm	304.8006
	inch	mm	25.4
Mass (weight)	pound	g	453.5924
	pound	kg	0.4535924
	pound	t (1000 kg)	0.00045359
	ton	kg	0.0002268
	ton	t (1000 kg)	0.9071847
Area	square mile	km ²	2.59000
	acre	m ²	4046.873
	acre	ha (10,000 m ²)	0.4046873
	square yard	m ²	0.83613070
	square foot	m ²	0.09290341
	square inch	mm ²	645.16
Volume	acre-foot	m ³	1233.49
	cubic yard	m ³	0.764559
	cubic foot	m ³	0.028317
	cubic foot	cm ³	28,317.02
	cubic foot	L (1000 cm ³)	28.31702
	gallon	L (1000 cm ³)	3.78541
	cubic inch	cm ³	16.387162
	cubic inch	mm ³	16,387.162
Velocity	mph	km/h	1.609347
Pressure or Stress	p.s.i.	Pa	6,894.757
	p.s.i.	kPa	6.894757
	k.s.i.	MPa	6.894757
	lbf/ft ²	Pa	47.88026
Force	pound-force	N	4.448222
	kip	N	4,448.222
Unit Weight	lbs./ft ³	kg/m ³	16.01846
	lbs./yd ³	kg/m ³	0.5932764
Flow	Cubic ft./min	m ³ /sec	0.000471947
	Cubic ft./sec	m ³ /sec	0.02831685

NOTE: All conversion factors are approximate and are based on the US Survey foot where 1 meter = 39.37 inches exactly.

Presented by: City of Las Cruces, Engineering Department; September 18, 2000
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