Norfolk Southern
Standard Specifications
for
Materials and Construction

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Norfolk Southern Railway Company
Engineering Department
Office of Chief Engineer – Design & Construction
Atlanta, GA

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Section GI – General Instructions

GI-1 Intent of Contract

The Work to be performed under this Contract consists of furnishing all materials, unless furnished by the COMPANY, superintendence, labor, equipment, tools, supplies and transportation required to complete the project and the carrying out of all the duties and obligations imposed by the Contract.

GI-2 General Conditions

A. Work to be performed under this Contract shall be in accordance with either the Norfolk Southern "Project Contract", Form 11133, or "Service Order", Form 11515.BB, incorporated herein as Appendix No. 1 and made part hereof, applicable plans and these Specifications. Any conflict between the plans, these Specifications and local requirements shall be resolved by following the most restrictive requirements.

B. The CONTRACTOR shall, at its sole cost and expense, provide insurance as stated in either the "Project Contract" or "Service Order."

C. Performance, Labor and Material Payment Bond shall be required as stated in the "Project Contract."

D. The COMPANY and its representative (the “ENGINEER”) reserve the right to make revisions to these Specifications. Any revisions to these Specifications shall be documented by letter from the COMPANY to the CONTRACTOR.

E. The quantities shown on the bid sheet are estimates and may be changed. Final quantities will be measured by the ENGINEER to determine actual payment for work performed. No extra compensation above the unit Contract prices will be allowed due to changes in final quantities.

F. It shall be the responsibility of the CONTRACTOR to alert the COMPANY in writing of any intent to claim extra compensation, prior to performing extra work. Any extra work must first be approved in writing by the ENGINEER. No additional compensation will be paid for any such extra work if it is performed prior to the CONTRACTOR's receipt of the ENGINEER's written approval thereof.

G. If the CONTRACTOR sublets the whole or any part of the work to be done under the Contract, it shall not, under any circumstances, be relieved of any liability or obligations under the Contract by reason of any such subcontract or subcontractor. All COMPANY communications pertaining to CONTRACTOR's performance of the Contract may be with the CONTRACTOR only.

H. The CONTRACTOR shall provide security for his equipment, materials, and COMPANY supplied materials receipted by the CONTRACTOR against theft and vandalism.

I. The CONTRACTOR shall be supplied with one set of the plans. The CONTRACTOR shall be responsible for production of the necessary copies for itself and any subcontractors. If plans are revised, the CONTRACTOR shall be supplied a copy of the revised plan sheet(s).

J. The COMPANY reserves the right to perform or award a separate contract for removing track and/or constructing track. The COMPANY reserves the right to eliminate or reduce the amount of track work to be done by the CONTRACTOR during duration of the project.

K. The COMPANY reserves all rights pertaining to Federal preemption of local zoning and other permitting requirements. The CONTRACTOR must notify the COMPANY before contacting or submitting documents to local permitting authorities, and any submittals must be approved by the COMPANY before submission.

L. The ENGINEER or another authorized COMPANY representative must be present whenever a Government official visits the site.

GI-3 Reference Standards

A. When a standard is specified by reference, the CONTRACTOR shall comply with requirements and recommendations stated in the standard, except when requirements are modified by the Contract Documents, or applicable codes establish stricter standards.

B. The CONTRACTOR shall obtain, at its expense, copies of the following reference standards directly from publication source, when needed or proper performance of work, or when required for submittal by Contract Documents.

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ANSI	American National Standards Institute
AREMA	American Railway Engineering & Maintenance-of-Way Association
ASA	American Supply Association
ASSE	American Society for Sanitary Engineering
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
CISPI	Cast Iron Soil Pipe Institute
CSA	Canadian Specification Association

FS Federal Standard

MSS Manufacturers Standardization Society of the Valves and Fitting Ind., Inc.

NFPA National Fire Protection Association

Local Building Codes and Zoning Regulations

State Department of Transportation or Highways

U.S. Army Corps of Engineers Specifications

GI-4 Safety

A. The CONTRACTOR and all personnel must follow all applicable railroad and governmental rules, with particular attention paid to railroad operating rules, COMPANY rules for the conduct of contractors, COMPANY rules for the operation of moving vehicles, and Federal Railway Administration roadway worker rules.

B. The CONTRACTOR shall require that its employees or employees of any subcontractors wear while on or about the COMPANY's property:

1. Appropriate head protection.

2. Appropriate eye protection.

3. Appropriate hearing protection.

4. Appropriate respiratory protection.

5. Appropriate safety vests are required for work inside active intermodal facilities, public rights-of-way, or other locations as required by the COMPANY.

6. Suitable protective clothing and footwear. Working in shorts is prohibited. Shirts must cover shoulders, back and abdomen. Working in tennis or jogging shoes, sandals, boots with high heels, cowboy and other slip-on type boots is prohibited. Hard sole, lace up footwear, zippered boots or boots cinched up with straps which fit snugly about the ankle are adequate. Safety boots are strongly required.

7. All protective equipment must be in good condition and properly fitted.

C. The CONTRACTOR shall observe the safety provisions of applicable laws and building and construction codes shall be observed. Machinery and equipment and other hazards shall be guarded in accordance with the safety provisions of the most recent edition of the Manual of Accident Prevention in Construction, published by the Associated General Contractors of America, to the extent that such provisions are consistent with applicable law or regulation.

D. The CONTRACTOR shall permit only qualified personnel to perform welding. Proper clothing, gloves and shields must be worn for body and eye protection. All welding equipment must be properly tested and in good working order. All welding equipment and cutting torches being used within 25 feet of the track must be shut off and work stopped when train is passing.

E. Anyone working on COMPANY property found to be under the influence of alcohol or other intoxicant, narcotic or hallucinogenic drug, or in possession of such intoxicant or drug, shall be dismissed from the property by the CONTRACTOR and not allowed to return.

F. When anyone working on COMPANY property is injured, the CONTRACTOR shall arrange for emergency medical assistance, if needed, and the CONTRACTOR shall notify ENGINEER of such incident by the quickest method of communication available.

G. The CONTRACTOR shall not permit the use of defective or improvised tools and equipment for the Work.

H. At the direction of the ENGINEER, the CONTRACTOR shall work with local emergency response personnel to develop action plans to respond to emergency situations.

I. The CONTRACTOR is responsible for maintaining emergency site access(es) for local emergency response personnel.

J. The CONTRACTOR must promptly notify ENGINEER of any safety incident or injury involving any person(s) on the project site.

K. The CONTRACTOR shall hold daily safety briefings involving all personnel working on site per railroad safety rules. Personnel arriving onsite after the safety briefing shall be briefed before proceeding with their work. The CONTRACTOR and all personnel shall hold additional safety briefings during the day as conditions or work changes.

L. The CONTRACTOR is responsible for obtaining eRailSafe certification for itself and its employees working onsite. The CONTRACTOR shall follow all eRailSafe requirements and escort all subcontractors or non-certified employees on site.

M. The CONTRACTOR and all personnel are responsible for obtaining FRA Roadway Worker certification through an NSR-approved trainer.

GI-5 Ecology and Hazardous Commodities

A. The CONTRACTOR shall comply with all federal, state and local laws, rules, regulations and ordinances controlling air, water, noise, solid wastes and other pollution relating to the storage, transport, release or disposal of hazardous materials, substances, or waste.

B. The CONTRACTOR shall, at its own expense, make all modifications, repairs, or additions to the CONTRACTOR's equipment and shall install and bear the expense of any and all structures, devices or equipment which may be required under any laws, rules, regulations or ordinances pertaining to the protection of the environment.

C. The CONTRACTOR shall not dispose of any wastes of any kind, whether hazardous or not and including without limitation construction and demolition debris, on any premises owned, operated or controlled by the COMPANY. The CONTRACTOR shall furnish the COMPANY written notice of any and all releases of hazardous wastes or substances whenever such releases are required to be reported to any federal, state or local authority. Such written notice shall identify the substance released, the amount released, and the measures undertaken to clean up and remove the released material and any contaminated soil or water, and CONTRACTOR shall certify that no contamination remains.

D. The CONTRACTOR shall provide the COMPANY with copies of any and all reports made to any governmental agency which relate to the use or occupancy of the COMPANY's premises.

E. If material is found that requires special handling, the CONTRACTOR shall immediately notify the ENGINEER. The CONTRACTOR shall receive no additional compensation for delays to his work caused by the cleanup of any material.

GI-6 Field Engineering

A. The COMPANY shall perform the necessary initial surveying work to establish horizontal and vertical control points and construction layout.

B. The CONTRACTOR shall be responsible for working from such control points and preserving these control points until construction is completed.

C. Any restaking required by the COMPANY as a result of the CONTRACTOR's carelessness or failure to protect control points or construction stakes shall be accomplished at the expense of the CONTRACTOR.

GI-7 Work Adjacent to or On Operating Tracks

A. The CONTRACTOR's action(s) shall not interfere with normal train operations. The CONTRACTOR shall provide weekly forecast of activities that may affect train operations or requiring flag protection.

B. The COMPANY will provide service outages only when absolutely required for construction activities, as determined by the ENGINEER and the COMPANY. No claim by the CONTRACTOR against the COMPANY will be allowed for delay caused by the COMPANY's operations.

C. When working on or near operating tracks to be kept in service, the COMPANY may provide a schedule of allowable work periods. Allowable work periods may change due to the variances in train operations. If the CONTRACTOR fails to comply with the

schedules and performs its work in a manner that causes delay to the COMPANY's train operations, it shall be liable for any delays and shall reimburse the COMPANY upon receipt of bills therefore. If at any time it is required to work longer than a normal 8 hour day to prevent disruption to the COMPANY's train operations, then the CONTRACTOR shall do so at no expense to the COMPANY.

D. The COMPANY shall provide flagmen, at no expense to the CONTRACTOR, at locations the ENGINEER may deem necessary for the safety of the COMPANY's property and operations. The CONTRACTOR will assure that its officers, agents, suppliers, subcontractors, and employees strictly observe the flagging directions given by the COMPANY flagman. It is distinctly understood, however, that no direction or failure to give direction by the COMPANY flagman will relieve the CONTRACTOR from any of its indemnification commitments in the Contract.

E. No one shall be allowed within 15 feet of the centerline of the nearest track without specific authorization of the COMPANY flagman.

F. No one shall be allowed to cross tracks without specific authorization of the COMPANY flagman.

G. All persons working near track while train is passing are to look out for dragging bands, chains and protruding or shifted cargo.

H. No one shall be allowed to pass between, over or under rail cars.

I. No steel or metallic chain or measuring tape shall be allowed to cross or touch rails without permission of the COMPANY flagman.

J. No construction materials shall be placed on tracks without the approval of the ENGINEER.

K. When working on tracks, switches shall be lined away from the work area and switch points spiked down or clamped or rail ends mismatched to prevent cars or engines from entering the work area.

L. No crane or boom equipment shall be allowed to set up to work or park within boom distance plus 15 feet of the centerline of track without specific permission of the COMPANY flagman or authorized COMPANY representative.

M. No crane or boom equipment shall be allowed to foul track or lift a load over the track without flagging protection and track time.

N. All workmen and machine operators shall stay with their machines when crane or boom equipment is pointed toward the track.

O. All cranes and boom equipment, including pile driving equipment, shall stop work and clear track while train is passing.

P. Swinging loads shall be secured to prevent movement while train is passing.

Q. No loads shall be suspended above a moving train.

R. No equipment or load movement shall be allowed within 25 feet above a standing train or railroad equipment without specific authorization of the COMPANY flagman.

S. No trucks, tractors or other equipment shall touch the ballast line of track without specific permission of the ENGINEER or COMPANY flagman.

T. All operating equipment within 25 feet of the nearest track must halt operations when a train is passing. All other operating equipment may be halted by the COMPANY flagman if he deems the operation to be dangerous to a passing train.

U. All equipment loads and cables shall be prohibited from touching the rails.

V. All cranes and boom equipment shall be turned away from the track and secured to prevent movement after each work day or whenever unattended by an operator.

GI-8 Construction Procedures

A. The CONTRACTOR shall plan his work, in coordination with COMPANY supervision or the ENGINEER, so as to complete this project as quickly as possible without interference to other contractors or to the COMPANY's operations. The CONTRACTOR shall provide method of construction, including sequence and detail, when requested by the ENGINEER.

B. The CONTRACTOR shall provide the ENGINEER with an advance daily report of his planned area of operation, his proposed actions and his hours of operation for that day. Any changes to the report shall be made to the ENGINEER.

C. The COMPANY shall provide copies of any permits issued by federal, state, or local regulatory agencies for any of the Work. Typically these permits pertain to erosion and sediment control, at-grade rail grade crossings, crossings of waterways, and the use of government owned land. The CONTRACTOR shall be responsible for complying with these permits and will keep a copy at the jobsite during construction.

D. The CONTRACTOR shall procure, at its expense and in a timely manner, all permits, licenses, surveys, inspections, certificates and authorizations, of any description, that may be necessary for the performance and completion of the Work as required by the Contract. The CONTRACTOR shall furnish the ENGINEER all certificates of inspection for any part of the work for which a certificate is required.

E. The CONTRACTOR shall be responsible for obtaining and maintaining any necessary permits from the state, city, and county for working within the right of way of roads. These permits shall be at the CONTRACTOR's expense and no separate pay item shall be set for such permits.

F. The CONTRACTOR is responsible for the ingress and egress of its plant, equipment, materials and labor to and from the construction site(s) in accordance with the following:

1. No movement that may endanger the safe normal COMPANY operations shall be made without the approval of the ENGINEER as to route and time of use.

2. No movement of the CONTRACTOR's plant, equipment, materials and labor to and from the construction site shall be made without the approval of the ENGINEER.

3. COMPANY regulations concerning the movement of vehicles on COMPANY property shall be followed by the CONTRACTOR, its subcontractors, and all of their respective personnel, including, without limitation, weight restrictions for roadways.

4. Use of access routes shall not cause the fouling of turnouts, flangeways, equipment, and drainage facilities with gravel, mud, waste materials, or timbers used for crossing tracks. Such routes shall be planned in such a way to minimize risk of damage to COMPANY facilities and must be approved by the ENGINEER.

5. Grade crossings:

   a. The CONTRACTOR shall, if necessary, construct at its own expense any new grade crossings or improve existing grade crossings to permit the safe passage of material, equipment and personnel.

   b. Crossings shall be constructed and used only at times approved by the ENGINEER.

   c. The CONTRACTOR, at its own expense, shall remove any new crossings upon completion of the project. The Work will not be considered complete until such removal work is accomplished.

   d. CONTRACTOR may be required to execute the COMPANY's standard private grade crossing agreement for each crossing installed. Crossings used for construction activities and within the project area do not require a grade crossing agreement.

G. Any costs incurred by the COMPANY for repairing damaged track or other facilities resulting from the operations of the CONTRACTOR shall be paid by the CONTRACTOR to the COMPANY.

H. The CONTRACTOR shall be responsible for delivery of COMPANY furnished materials to the job site from location(s) designated by the COMPANY. Work shall include unloading of materials furnished in rail cars. The CONTRACTOR shall count material and verify the count with the ENGINEER and accept responsibility for such material. The CONTRACTOR shall clean debris and trash out of cars and dispose of waste off-site in approved landfills and in accordance with appropriate laws and regulations.

I. No material to be furnished by the CONTRACTOR shall be ordered until approved by the ENGINEER.

J. Public and private roads are to be kept open to traffic at all times or as required by authorities exercising control over the roads. Any damage to roads, including public or private property occurring by reason of the operations or activities of CONTRACTOR or any of its subcontractors, shall be repaired and at the expense of the CONTRACTOR.

K. The CONTRACTOR shall perform the Work within the property of the COMPANY. The CONTRACTOR shall not encroach upon property of others with construction of railroad facilities. The CONTRACTOR shall make no claims on the COMPANY for delays or work stoppage due to any public or private action resulting from CONTRACTOR's operation on public or other private property.

L. The CONTRACTOR shall provide and maintain, at its expense, any barricades, signs, warning devices or flagmen to restrict access of the public to the construction site, as may be necessary for safe operations as the ENGINEER deems necessary.

M. No part of crane, boom equipment or the load, conductive equipment, or a person shall be permitted to come within 15 feet of electric power lines unless the lines have been de-energized. When it becomes necessary to work with such equipment closer than 15 feet, CONTRACTOR must contact the appropriate utility COMPANY or utility notification center to make arrangements to de-energize the line or provide other means of protection.

N. The CONTRACTOR shall be held responsible for protection of any portion of the project and for all materials and equipment used in construction, until project is completed by the CONTRACTOR and accepted by the COMPANY. Portions of the Work completed by the CONTRACTOR may be approved and accepted by the COMPANY if the use of such Work for its intended purpose is independent from the remainder of the project, is available for use by the COMPANY, and the COMPANY has need for that portion of the Work independent of the project. Such partial approval shall be solely at the discretion of the COMPANY.

O. If a Critical-Path-Method (CPM) chart is prepared, the CONTRACTOR shall progress the project in the manner set forth in the CPM chart. If the CONTRACTOR's work becomes behind CPM schedule, it shall take appropriate steps to meet and maintain the established schedule of construction.

P. The CONTRACTOR shall periodically clean the construction site of all waste, rubbish, and unused construction materials. The removal and disposal of waste and debris shall be the responsibility of the CONTRACTOR. Unused construction materials shall be stockpiled in an orderly fashion. The CONTRACTOR shall sweep pavement for construction debris as directed by the ENGINEER. No extra payment will be made for sweeping pavement.

Q. Upon completion of the project, all unused construction material, scrap, asphalt and other construction and demolition debris, rubbish, etc., shall be removed from the site by the CONTRACTOR and the same shall be disposed of by the CONTRACTOR as required

by applicable laws and regulations, all at the expense of the CONTRACTOR. The Work will not be considered complete until such removal is accomplished.

GI-9 Field Offices

A. If required on the project Plans and Bid Documents, CONTRACTOR shall provide and maintain a separate field office for the use of the ENGINEER. All installation, operation, removal, utility, and other costs associated with the field office shall be covered by the CONTRACTOR. No separate payment will be made for field offices.

B. The COMPANY shall reimburse the CONTRACTOR for any long-distance calls placed by the ENGINEER. Reimbursements shall be paid on a monthly basis.

C. Field offices shall be removed upon the completion and acceptance of the Work. Field office shall remain the property of the CONTRACTOR, and no payment shall be made for removal of the field office.

D. Field office locations shall be approved by the ENGINEER.

E. Unless otherwise noted, field offices shall conform to the following layout requirements:

1. Minimum size:

   a. Type A – 200 square feet with two rooms

   b. Type B – 400 square feet with three rooms

2. Minimum interior height: 7.5 feet

3. Minimum width: 8.0 feet

4. Minimum room size: 64 square feet

5. Offices shall include a closet and a washroom with sanitary service.

F. CONTRACTOR shall provide and maintain the following utility services:

1. Oil, gas, or electric heating.

2. Air conditioning.

3. Telephone service with one line per room and one line for a fax machine.

4. Sanitary services.

5. Potable water.

6. High-speed internet service.

7. Janitorial/trash service.

G. CONTRACTOR shall provide and maintain the following furniture or appliances:

1. First aid kit.
2. Fire extinguisher.
3. One desk per room. Desks shall include overhead and underdesk cabinets and formica tops.
4. Drafting table.
5. One plan cabinet.
6. All-in-one copier (copy, print, fax, scan).
7. Four-drawer fire-resistant file cabinet.
8. Four-drawer file cabinet.
9. Two folding tables.
10. Eight chairs.

END OF SECTION

Section AB – Abbreviations, Acronyms, and Definitions

AB-1 Typical Abbreviations and Acronyms

AAMA:	American Architectural Manufacturers Association
AASHTO:	American Association of State Highway and Transportation Officials
ACI:	American Concrete Institute
AGS:	Automatic Gate System
API:	American Petroleum Institute
ANSI:	American National Standards Institute
AREMA:	American Railway Engineering and Maintenance Association
ASA:	American Supply Association
ASME:	American Society of Mechanical Engineers
ASSE:	American Society of Sanitary Engineering
ASTM:	American Society of Testing and Materials
AWS:	American Welding Society
AWWA:	American Water Works Association
BCCMP:	Bituminous coated corrugated metal pipe
BMP:	Best Management Practice
CISPI:	Cast Iron Soil Pipe Institute
CL or C/L:	Centerline
CPM:	Critical-Path-Method
CSA:	Canadian Specification Association
CWR:	Continuous Welded Rail
CY:	Cubic yards
DGA:	Dense graded aggregate
DI:	Ductile Iron

EA:	Each
EPA:	Environmental Protection Agency
FRA:	Federal Railroad Administration
FRSA:	Federal Railway Safety Act
FS:	Federal Standard
GA:	Graded Aggregate
Ga.:	Gauge
Gals.:	Gallons
HDPE:	High Density Polyethylene Pipe
ICCTA:	Interstate Commerce Commission Termination Act
IMF:	Intermodal Facility
LS:	Lump Sum
MSDS:	Material Safety Data Sheet
MSS:	Manufacturers Standardization Society of the Valves and Fitting Ind., Inc.
NAPCA:	National Association of Pipe Coating Applicators
NEC:	National Electrical Code
NEMA:	National Electrical Manufacturers Association
NFPA:	Nation Fire Protection Association
NSR:	Norfolk Southern Railway
NG:	Point of No Gage (PI of a turnout)
OD:	Outside Diameter
OSHA:	Occupational Safety and Health Administration (Federal)
PCC:	Portland Cement Concrete
PS:	Point of Switch
PF:	Point of Frog

PVC:	Polyvinyl Chloride
RCP:	Reinforced Concrete Pipe
RCC:	Roller Compacted Concrete
SDR:	Standard Dimension Ratio (Ratio of pipe diameter to wall thickness)
SY:	Square Yards
TEFC:	Totally Enclosed Fan Cooled
TF:	Track Foot
TOR or T/R:	Top of Rail
UL:	Underwriters Laboratory

AB-2 Typical Definitions

Aggregate

The aggregate material, such as sand, gravel, shells, slag or broken stone or combination thereof, with which cement or bituminous materials is mixed to form a mortar or concrete. "Fine aggregate" may be considered as the material that will pass a ¼ inch screen. "Coarse aggregate" is the material that will not pass a ¼ inch screen.

Backfill

The material used to refill a ditch or other excavation, or the process of doing so.

Ballast

Rock or gravel meeting NSR specifications used to support cross ties and rails and to aid in holding the desired track geometry.

Bank

The sides of a channel between which the flow is normally confined.

Bedding Layer

The layer of earth or other type material on which a pipe or conduit is supported.

Channel

The bed and banks that confine the surface flow of a stream.

Continuous Welded Rail (CWR)

Traditionally, track was laid in lengths of 39' with a joint between each to allow for expansion and contraction due to heat and cold. Joints were points of high maintenance. Continuous Welded Rail typically consists of 1,440 feet in length and joints between them are eliminated by in-place welding using portable equipment. Without joints, expansion and contraction can result in buckling in high temperatures and breaking in cold conditions.

Crib

The space between adjacent ties.

Cross Tie

The transverse member of the track structure to which the rails are spiked or otherwise fastened to provide proper gage and to cushion, distribute and transmit the stresses of traffic through the ballast to the roadbed.

Crosslevel

The vertical relationship between two rails on the same track. Where both rail treads are of equal elevation, the track is considered having zero cross level at that point.

Curvature

The angle subtended at the center of a curve by a 100 foot chord.

Deflection

The amount of downward vertical movement of a surface due to the application of a load to the surface.

Dense Graded Aggregate

A continuous grading from a designated maximum size to dust to provide maximum density after compaction.

Density

Mass per unit volume, can be expressed as unit weight per cubic foot (excluding water) as measure of the degree of compaction.

Depth (Ballast)

The distance from the bottom of the tie to the top of the subballast.

Derail

Derails are mechanical devices in the track that intentionally derail a car or train. The idea behind a derail is that it is often better to derail a car rather than to have it continue on the track and cause more damage to life or property. Typically derails are used to prevent trains from running through an open bridge, or are set as a safety measure to protect workers or other trains.

Discharge

Volume of water passing through a channel during a given time.

Embankment

A mass of soil, rock or other type material constructed above the natural ground surface.

Erosion

Displacement of soil particles due to water or wind action.

Filter Fabric (cloth)

Geosynthetic fabric that serves as a filter.

Fine Graded Aggregate

Mineral aggregates which will pass a No. 4 mesh screen and be retained on No. 200 screen.

Frog

A track structure used at the intersection of two running rails to provide support for wheels and passageways for their flanges, thus permitting wheels on either rail to cross the other.

Gage (of Track)

The distance between the rails, measured at right angles thereto 5/8 inches below the top of the rail. (Standard gage is 4 feet 8-1/2 inches or 56-1/2 inches.)

Graded Aggregate

A term describing mineral aggregate in which there is a continuous grading in the sizes of mineral fragments from coarse to fine, the coarse sizes being may times the diameter of the finer sands.

Invert

The lowest point in the channel cross section or at flow control devices such a weirs,

culverts or dams.

Impervious

Material of low permeability, generally resisting entrance of liquids.

Joint, Rail

Joint Bar, also known as an Angle Bar – A fastening designed to unite the abutting ends of rail.

Liquid Limit (LL)

The moisture content at which soils change from a plastic state to a liquid state.

Open Graded Aggregate

Aggregate graded to a narrow size range with few, if any, fines designed to provide rapid internal discharge.

Pandrol Clip

Where used, a "G" shaped piece of metal used to attach the rail to the crosstie with a specified type of tie plate.

Panel Track

Sometimes when new track is needed, track is assembled on ties at another location and transported to the work site. The panel pieces are then set into place and bolted together.

Plastic Limit (PL)

The moisture content at which a soil changes from a semi-solid state to a plastic state.

Plasticity

The property of a soil or rock which allows it to be deformed beyond the point of recovery.

Plasticity Index

The numerical difference between the liquid limit and the plastic limit.

Plug, Tie

Rectangular sections of wood, somewhat like spikes, for driving into holes from which spikes have been withdrawn.

Profile

A line representing the ground surface or an established grade line, or both, in relation to the horizontal. The top of rail geometric position of a track expressed over its length.

Rail (Track)

A rolled steel shape, commonly a T-section, designed to be laid end to end in two parallel lines on crossties or other suitable supports to form a track for railway rolling stock. It has three main parts:

i. The head that comes into contact with car wheels.

ii. The web, which is the thinner, middle part of the rail; and

iii. The base

Rail Anchors

Rail anchors are fastening devices that put contact pressure on the rail to keep it stationary. Rail anchors are used with CWR to prevent longitudinal movement due to thermal expansion or train movement.

Rail Clip

A rail fastener component that provides rail rotational resistance about the longitudinal axis of the rail.

Rail Fastener

Any system of components which fasten a railroad rail to a cross tie or to a support base.

Rail Seat

The area of the tie plate or resilient fastener that supports the rail.

Riprap

Layer or facing of rock or broken concrete dumped or placed to protect a structure or embankment from erosion; also the rock or broken concrete suitable for use. Riprap has also been applied to almost all kinds of armor, including wire-enclosed riprap, grouted riprap, sacked concrete and concrete slabs.

Runoff

The portion of precipitation that does not soak into the ground, but flows on the surface as either sheet flow, shallow flow, or stormwater flow through drainage structures or channels.

Shoulder of Track

The outside portion of the track comprised of the ballast. The width of the shoulder is usually expressed as the level top portion of the ballast up to the point where it begins to slope down.

Spike

Square steel rods, with a tapered end and off-set head, used for attaching the rail to the crosstie.

Subballast

Any material of a superior character meeting NSR standards, which is spread on the finished subgrade of the roadbed and below the top ballast, to promote stormwater runoff, prevent upheaval by frost, and better distribute the load over the roadbed.

Subgrade

The top, finished surface of a roadbed directly below the planned pavement, subballast, or dense graded aggregate course.

Superelevation

As a train goes around a curve, the cars tend to tip towards the outside of the curve, especially with tall and top-heavy loads. To compensate, the outside rail is raised or superelevated to force the load back toward the inside of the curve. The amount of superelevation is determined by the degree of the curve and the intended train speed.

Switch

A track structure used to divert rolling stock from one track to another.

Switch Tie

The transverse member of the track structure which is longer than but functions as does the cross tie and in addition supports a crossover or turnout.

Tangent

Any straight portion of a railway alignment.

Tie

The lateral connection that supports the two rails in a track structure (typically wood or steel).

Tie Plate

A part of the track structure placed under the rail to distribute the wheel to the tie, cant the rail to the desired angle, assist in maintaining the track to gage and protect the tie. The tie plate has a rail seat, either flat or canted, either a single or double shoulder parallel to the rail it supports, and is punched with holes for spikes or other fasteners. The bottom of the tie plate is usually flat, but ribbed or other designs may be used.

Turnout

An arrangement of a switch and a frog with closure rails, by means of which rolling stock may be diverted from one track to another.

END OF SECTION

Section BM – Surveying Monuments

BM-1 Description

Work involves installation of permanent survey monuments at locations designated by the COMPANY or the ENGINEER.

BM-2 Material

A. Concrete shall meet local State specifications for general-purpose concrete with a minimum strength of 3,000 psi. Only concrete with Type I, IA, III, or IIIA Portland cement may be used for the monument. The use of pre-mixed bagged concrete products will be allowed only with approval of the ENGINEER.

B. Rebar shall be intermediate grade, new deformed billet steel. Rebar shall be free from dirt, paint, oil, grease, thick rust, and other foreign substances. Rebar shall be No. 4 or greater.

C. Survey disks shall be anchored into concrete foundations using anchoring cement, grout, or epoxy cement intended for use in exterior applications. Material shall have non-shrink properties and be intended for use in anchoring bolts. Epoxy cement shall be resistant to ultraviolet degredation and hold up to all weather conditions.

D. Witness post shall be orange and 5 feet in length.

E. Survey disks shall be supplied by the COMPANY.

BM-3 Installation

A. Requirements for survey disks set in new concrete:

1. The top of the monument shall be constructed as close to natural or finished ground as possible. Should field conditions warrant, monuments may be placed with top elevations a maximum of 6 inches above ground. Circular forms must be used for monuments protruding above the ground.

2. A 12-inch diameter circular hole shall be dug by hand or hand-operated powered augur. The hole shall be dug to at least 1 foot below the frost line, but must be a minimum of 4 feet deep. The bottom of the hole shall be enlarged 2 inches in radius by hand-tamping to create a bell shape for the bottom 1 foot of the hole.

3. Rebar is to be carefully placed in the concrete to avoid creating voids and coming into contract with the ground.

4. Concrete is to be carefully placed to avoid disturbing the sidewall of the hole and contaminating the concrete.

5. Survey disks shall be set in the center of the concrete monument. CONTRACTOR should ensure that the disk is securely set and that the concrete is firmly tamped.

6. The top of the concrete shall be smoothed and tapered slightly away from the survey disk.

7. Concrete shall be protected during curing per section SC – Structural Concrete.

B. Survey disks set in existing concrete:

1. CONTRACTOR shall ensure concrete is sound and stable with no visible cracks.

2. Drill hole to the width and depth required to install survey disk. Clean hole of debris and recess the area around the hole so that survey disks sits flush with the adjacent pavement.

3. Wet hole before anchoring survey disks with anchoring cement or non-shrink grout. Hole should remain dry if using epoxy cement. Follow manufacturer's instructions regarding temperature considerations.

4. Ensure disk is clean before setting. Place disk firmly into hole and rotate as needed to provide a proper bond. Work anchoring material around the edges of the disk, and remove excess material. Clean face of disk.

5. Protect disk from weather until fastener has cured.

6. Wherever practical, place witness post to protect monument.

BM-4 Measurement and Payment

A. Monuments shall be measured per each monument installed.

B. Payment shall be made per the Contract bid price per monument. Price shall include all labor, equipment, materials not furnished by the COMPANY, witness posts, and other incidentals required to complete the work.

END OF SECTION

Division II: Site Work

Section CG – Clearing and Grubbing

Section DM – Demolition

Section DR - Drainage

Section EF – Engineering Fabric and Geogrids

Section ES – Erosion and Sediment Control

Section GR - Grading

Section SM – Seeding & Mulching

Section CG – Clearing and Grubbing

CG-1 Description

The Work shall consist of clearing, grubbing, removing and disposing of all vegetation and debris, such as disconnected utility poles, drainage systems, including catch basins and manholes, or retaining walls that are within the limits of clearing, except objects as designated to remain or are to be removed in accordance with other sections of these Specifications. This work shall also include the preservation and protection of all vegetation and objects shown on the plans or as designated by the ENGINEER to remain.

The ENGINEER shall establish the clearing and grubbing limits.

CG-2 General Conditions

A. CONTRACTOR shall perform his work in full compliance with all federal, state and local statutes, laws, ordinances, regulations, rules and codes.

B. Before the clearing operation begins, the CONTRACTOR shall install temporary and permanent erosion and sediment control measures as shown on the plans or as directed by the ENGINEER in accordance with Section ES - Erosion and Sediment Control of these Specifications.

C. All stumps, roots, organic material, logs and other obstructions shall be grubbed and removed prior to grading operations.

D. Overburden stripped from cut and fill areas that is not suitable for fill construction but shall be disposed of off-site by the CONTRACTOR unless otherwise directed by the ENGINEER.

E. Materials from clearing may be used as brush barriers for erosion and sediment control as directed by the ENGINEER and in accordance with Section ES - Erosion and Sediment Control of these Specifications.

F. The use of explosives shall be prohibited.

G. Buildings, building components and appurtenances, septic tanks and other miscellaneous structures shall be demolished, removed and disposed of in accordance with Section DM - Demolition of these Specifications.

H. Water wells shall be abandoned in place in accordance with Section DM - Demolition of these Specifications.

I. All disconnected underground utilities found in excavated areas shall be removed and disposed of off-site by the CONTRACTOR.

CG-3 Construction Fence

A. The CONTRACTOR shall install a protective construction fence around trees to remain and other protected areas shown on plans. The barrier shall be maintained until completion of the project at which time it shall be removed and disposed of by the CONTRACTOR.

B. Materials:

1. Construction fence fabric:

a.	Material:	Polyethylene
b.	Color:	OSHA Orange
c.	Roll Width:	48” (+/- 0.5”)
d.	Aperture Size:	MD x TD - 3.75” x 1.75” (+/- 0.25”)
e.	Rib Thickness:	MD & TD: 1/8” (+/- 1/16”)
f.	Unit Tensile Strength:	MD – 100.33 N/strand / TD – 123.33 N/strand
g.	UV Resistance:	2 year exposure resistance
h.	Elongation at Break:	+50%
i.	Min. Temperature:	-85°F
j.	Max. Temperature:	195°F

2. Fence posts:

   a. Construction fence shall be supported every eight (8) feet on center with sixty-inch metal posts.

   b. Posts shall be constructed of high-carbon steel with a flanged leg section or flanged leg U-bar section. Post material thickness shall be not less than 1/8 inch, and shall not weigh less than 2 pounds per linear foot. Posts shall be galvanized and painted OSHA orange.

   c. Posts shall extend twelve (12) inches below grade.

3. Fence material shall be attached to post with at least five (5) wire ties. Wire ties shall be not less than 12.5 gauge.

C. The construction fence shall be at least four (4) feet high and be placed at least six (6) feet away from the base of any tree to remain. Fifty percent of the area under the dripline shall be included within the temporary barrier.

D. The CONTRACTOR shall not disturb the ground within six (6) feet of the base of trees located outside of the clearing limits and meeting the diameter requirements (for trees to remain) shown on the plans or as specified by the ENGINEER.

E. No materials, trailers, equipment, or chemicals shall be stored within the protective area for trees.

CG-4 Pavement, Curb and Sidewalk Removal

A. The CONTRACTOR shall remove existing concrete or asphalt pavement, concrete sidewalks and concrete or asphalt curbs shown to be removed on the plans or as directed by the ENGINEER.

B. Thickness of the pavement, sidewalks or curbs to be removed may vary and the CONTRACTOR shall be responsible for predetermining the actual thickness.

C. When portions of existing pavement, sidewalk or curbs are to remain in place, the CONTRACTOR shall remove only precut sections. The CONTRACTOR shall use caution during removal to prevent jagged or torn edges on remaining pavement, sidewalk or curb. Should jagged or torn edges occur during removal, the CONTRACTOR shall correct the condition by removing and replacing the damaged areas at no expense to the COMPANY.

D. If approved by the ENGINEER, and state or local ordinances, the CONTRACTOR may break removed concrete into 50 pound pieces for use as rip-rap. Reinforcing steel if present shall not protrude from pieces. No separate payment will be made for use of concrete as rip-rap.

CG-5 Drainage Removal

A. The CONTRACTOR shall be responsible for removing existing culvert pipes or drainage systems as shown on the plans or as directed by the ENGINEER.

B. Pipes, catch basins and manholes shall be removed by open trenching. Material shall become the property of the CONTRACTOR and be removed from the COMPANY's right of way.

C. Cavity left from removing pipes, catch basins and manholes shall be backfilled in accordance with Section GR - Grading of this Specification.

D. Pipes taken out of service but which shall remain in the ground will have a concrete plug inserted at both ends to seal the pipe. The CONTRACTOR is responsible for sealing both ends of the pipe even if one end is not identified on the plans.

E. Any pipe taken out of service and remaining in the ground beneath a paved surface or track shall be filled to refusal, as determined by the ENGINEER, with a cement grout.

F. Concrete for plugging pipes shall have a minimum strength of 3,000 psi after 28 days.

G. Grout mix for filling pipes shall consist of one part Type 1 Portland cement conforming to AASHTO M 85, three (3) parts sand and a sufficient quantity of water to produce a free flowing grout.

CG-6 Disposal

A. The CONTRACTOR shall handle, transport and dispose of all waste materials in compliance with all federal, state and local statutes, ordinances, rules and regulations.

B. The CONTRACTOR shall progress the clearing and grubbing work in an orderly fashion and the disposal work shall coincide with the clearing and grubbing in order that the waste materials shall not accumulate and cause an unsafe condition.

C. The CONTRACTOR shall be responsible for all disposal fees.

D. The CONTRACTOR shall load any miscellaneous track material located on the site into rail cars placed on a spur track as near as practicable to the site.

E. Burning shall only be allowed when it is authorized by local or state laws or ordinances. The CONTRACTOR shall obtain all necessary permits and comply with the applicable laws and ordinances and shall not interfere with the COMPANY's operations.

CG-7 Salvage

A. Any material salvaged by the CONTRACTOR shall become the property of the CONTRACTOR unless designated otherwise by the ENGINEER. COMPANY shall not be responsible for security of salvaged materials temporarily stored on the site.

B. Any material salvaged by the COMPANY shall be removed by and stored, at a location designated by the ENGINEER, by the CONTRACTOR.

CG-8 Clean-up

A. CONTRACTOR shall clear the site of all rubble and loose material after clearing and grubbing is complete and waste material has been disposed of.

B. CONTRACTOR shall backfill all voids left as a result of the clearing and grubbing operation in accordance with Section GR - Grading of these Specifications.

C. CONTRACTOR shall grade the areas cleared and grubbed to drain.

D. CONTRACTOR shall upon completion of the Work remove from the site all materials, salvage or otherwise, and equipment to leave a clear, clean site as determined by the ENGINEER. If the site is not cleaned in a timely manner after written notification to the CONTRACTOR by the COMPANY, COMPANY shall have the site cleaned by another CONTRACTOR and the cost shall be deducted from the CONTRACTOR's payment.

CG-9 Measurement and Payment

A. Measurement

1. The area cleared and grubbed shall be measured (horizontal measurement) by the ENGINEER and calculated in acres.

2. Construction fencing shall be measured per linear foot installed.

3. Concrete pavement removed shall be measured by the ENGINEER and calculated in square yards.

4. Asphalt pavement removed shall be measured by the ENGINEER and calculated in square yards.

5. Concrete sidewalks removed shall be measured by the ENGINEER and calculated in square yards.

6. Concrete curb removed shall be measured by the linear foot by the ENGINEER.

7. Asphalt curb removed shall be measured by the linear foot by the ENGINEER.

8. Unless otherwise specified, existing culvert pipe or drainage systems removed shall be measured by the linear foot by the ENGINEER.

9. Catch basins, manholes, or other utility or drainage structures removed shall be measured by each type of structure.

10. All linear and surface area measurements shall be based on planimetric measurements (two-dimensional planar surface projection). No allowance shall be made for pavement cross-slopes, crowns, or other vertical features.

B. Payment

1. Payment for clearing and grubbing will be made at the Contract unit bid price per acre for clearing and grubbing, which price shall include all costs for grubbing and disposition of the material, and all costs for clearing, which includes disposition of removed debris, clean-up, and the handling of the material for the construction of brush barriers and the maintenance, removal and disposition of the brush barriers.

2. Payment for construction fence shall be included in the bid price per linear feet installed. Payment shall include all materials, labor, maintenance, repairs, and transportation.

3. No separate payment will be made for landfill fees.

4. Payment for erosion and sediment control measures, except brush barriers, will be made in accordance with Section ES - Erosion and Sediment Control of these Specifications.

5. Payment for the removal of fence and disconnected utility poles shall be included in the Contract unit bid price per linear foot removed, unless included in the per-acre clearing and grubbing pay item on the bid sheet.

6. Payment for the removal and disposition of disconnected underground utilities shall be included in the Contract unit bid price per acre for clearing and grubbing.

7. The removal and disposition of topsoil in fill sections shall be considered incidental to clearing and grubbing. Payment shall be included in the Contract unit bid price per acre for clearing and grubbing. In cut sections top soil removal and disposition is measured and paid for per section GR - Grading.

8. Unless otherwise specified, payment for the removal of existing culvert pipe or drainage systems will be made at the Contract unit bid price per linear foot of pipe removed, which price shall include all necessary material, labor, equipment, and backfill.

9. Payment for the removal of concrete pavement will be made at the Contract unit bid price per square yard of concrete pavement removed, which price shall include all necessary material, labor and equipment.

10. Payment for the removal of asphalt pavement will be made at the Contract unit bid price per square yard of asphalt pavement removed, which price shall include all necessary material, labor and equipment.

11. Payment for the removal of concrete sidewalk will be made at the Contract unit bid price per square yard of concrete sidewalk removed, which price shall include all necessary material, labor, equipment, saw cutting, and disposal.

12. Payment for the removal of concrete curb will be made at the Contract unit bid price per linear foot of concrete curb removed, which price shall include all necessary material, labor, equipment, saw cutting, and disposal.

13. Payment for the removal of asphalt curb will be made at the Contract unit bid price per linear foot of asphalt curb removed, which price shall include all necessary material, labor, equipment, saw cutting, and disposal.

14. Payment for the removal of catch basins, manholes, or other utility or drainage structures shall be paid at the Contract unit bid price per each type of structure removed, which price shall all necessary material, labor, equipment, saw cutting, and disposal.

15. No separate payment will be made for removal of miscellaneous track material unless otherwise noted on the bid sheet. Payment for removal of miscellaneous track

material shall be as shown on the bid sheet, and shall include all necessary equipment, labor, transportation, and disposal.

16. All pay items shall include placement and compaction of suitable backfill into voids created by the removal of foundations or structures.

END OF SECTION

Section DM – Demolition

DM-1 Description

The Work shall consist of the complete demolition, removal and disposal of all buildings, building components and appurtenances, footings and other miscellaneous structures in accordance with these Specifications and as shown on the plans or as directed by the ENGINEER.

Items such as driveways, culverts, retaining walls, manholes, pump houses, sheds, etc. that are not appurtenances to a main structure shall be removed in accordance with Section CG - Clearing and Grubbing of these Specifications.

DM-2 General Conditions

A. The CONTRACTOR shall perform his work in full compliance with all federal, state and local statutes, laws, ordinances, regulations, rules and codes.

B. Prior to demolition work, the COMPANY shall inspect structures for asbestos-containing materials and complete and submit required National Emission Standards for Hazardous Air Pollutants (NESHAP) notice(s) to the United States Environmental Protection Agency (even if there is no asbestos present in the structure(s) or if the asbestos has been previously removed). The CONTRACTOR shall furnish the COMPANY the start and completion dates for the demolition work for inclusion in the notice(s). Under no circumstances shall any demolition work start sooner than the date specified in the notice and in advance of instructions from the ENGINEER. All efforts must be made to complete the demolition work as set forth in the notice. The CONTRACTOR shall immediately notify the ENGINEER if any delay in the demolition work commencement occurs due to bad weather or force majeure. The COMPANY shall contract separate any asbestos abatement work with contractors trained in asbestos removal.

C. Demolition shall extend to 1 foot below ground or to bottom of foundation in the case of a structure unless otherwise shown on the plans or designated by the ENGINEER.

D. The use of explosives shall be prohibited.

E. The CONTRACTOR shall install temporary and permanent erosion and sediment control measures as shown on the plans or as directed by the ENGINEER in accordance with Section ES - Erosion and Sediment Control of these Specifications.

F. A septic tank that serves a building that is being demolished shall be removed or abandoned in place in accordance with local codes as specified on plans and instructions from the ENGINEER.

G. A water well that serves a building that is being demolished shall be abandoned in place in accordance with local codes as specified on plans and instructions from the ENGINEER.

DM-3 Permits

The CONTRACTOR shall be responsible for the securing of all permits, except the NESHAP notice(s), that may be required and the payment of all fees in connection therewith.

DM-4 Signs and Barricades

The CONTRACTOR shall post all signs and provide barricades to protect the COMPANY's employees and the general public.

DM-5 Utilities

The CONTRACTOR shall be solely responsible for making necessary arrangements and for performing any necessary work, in accordance with local ordinances, involved with the disconnection or interruption of public utilities or services, including but not limited to gas, water, sewer, electricity and telephone, which may be affected by the work to be performed under the demolition specified herein.

DM-6 Disposal

A. The CONTRACTOR shall handle, transport and dispose of all waste materials, including without limitation construction and demolition debris, in compliance with all federal, state and local statutes, ordinances, rules and regulations.

B. The CONTRACTOR shall progress the demolition in an orderly fashion and the disposal work shall coincide with demolition in order that the waste materials shall not accumulate and cause an unsafe condition.

C. The CONTRACTOR shall be responsible for all disposal fees.

DM-7 Salvage

A. Any material salvaged by the CONTRACTOR shall become the property of the CONTRACTOR unless designated otherwise by the ENGINEER. The COMPANY shall not be responsible for security of salvaged materials temporarily stored on the site.

B. Any material identified to be retained by the COMPANY shall be removed by the CONTRACTOR and stored, at a location designated by the ENGINEER.

DM-8 Clean-up

A. The CONTRACTOR shall clear the site of all rubble and loose material after demolition is complete and waste material has been disposed of.

B. The CONTRACTOR shall backfill all voids left as a result of the demolition. Backfill material shall meet the requirements for backfill material in Section GR - Grading of these Specifications.

C. The CONTRACTOR shall grade the areas of demolition to drain.

D. The CONTRACTOR shall seed and mulch the area in accordance with Section SM - Seeding & Mulching of these Specifications.

E. The CONTRACTOR shall upon completion of Work remove from the site all materials, salvage or otherwise, and equipment to leave a clear, clean site as determined by the ENGINEER. If the site is not cleaned in a timely manner after written notification to the CONTRACTOR by the COMPANY, the COMPANY shall have the site cleaned by another CONTRACTOR and the cost shall be deducted from the CONTRACTOR's payment.

DM-9 Measurement and Payment

A. Measurement

1. Demolition shall not be measured separately for payment when lump sum unit is shown on the Schedule of Prices.

2. When payment for demolition will be made on a Contract unit bid price, demolition shall be measured in the units shown on the Schedule of Prices.

B. Payment

1. Payment for demolition will be made at the Contract lump sum bid price or at the Contract unit bid price as shown on the Schedule of Prices, which price shall include all necessary material, labor, equipment, permit fees, disconnection of utilities, hauling and dumping fees, and clean-up. Price shall also include backfilling the foundation void left over from demolition in accordance with section GR – Grading.

2. Payment for removal of septic tanks or abandoning water wells shall be paid at the Contract unit price per each type removed or abandoned. The unit bid price shall include all labor, material, and equipment required.

3. No additional payment shall be made for temporary traffic control, including furnishing, installing, and removing temporary signs and barricades.

END OF SECTION

Section DR – Drainage

DR-1 Description

The Work shall consist of the furnishing and installation of all drainage structures and shall include trenching, excavation, placement of bedding material, pipe installation, installation of drop inlets, catch basins, and manholes and backfilling.

DR-2 Material

A. General

1. The CONTRACTOR shall be responsible for locating the exact location of any existing sewer lines, water lines and/or any other utilities that may conflict with the installation. The CONTRACTOR shall endeavor to install the drainage structures without interrupting service and/or damaging other utilities. However, should service be interrupted and/or damage occur during the installation, the CONTRACTOR shall be responsible for quickly restoring service and/or repairing damage at no cost to the COMPANY.

2. The CONTRACTOR shall be responsible for keeping pipes, catch basins and other drainage structures free of silt and other debris, in accordance with Section ES - Erosion and Sediment Control of these Specifications, throughout the duration of the project until final acceptance. Silt or debris deposited in pipes, catch basins, or other drainage structures shall be removed by the CONTRACTOR. Inlet or outlet ditches shall also be cleaned of similar materials and reshaped to the cross sections and profiles shown on the plans.

3. CONTRACTOR-furnished materials for pipe, catch basins, drop inlets and manholes shall conform to the required length/height, diameter and gage or class as shown on the plans.

4. Bedding and select backfill material shall conform to Category B dense graded aggregate in accordance with Section GA – Graded Aggregate of the NS Standard Specifications unless stated otherwise by the design ENGINEER or plans.

5. Metal pipe flared end sections shall conform to the requirements of AASHTO M 218. The thickness of end sections shall be 12 gage.

6. Concrete for use as a collar when joining pipes of dissimilar materials shall consist of Type I or Type II Portland cement conforming to the requirements of AASHTO M 85. The concrete mix shall be as shown on the plans. If a mix is not designated on the plans, CONTRACTOR shall submit a mix design, with a minimum 28 day compressive strength of 4,000 psi, to the ENGINEER for approval.

7. Grout mix shall consist of one part Type 1 Portland cement conforming to the requirements of AASHTO M 85, three parts sand and a sufficient quantity of water to produce a free flowing grout.

8. Precast concrete structures shall be constructed as shown on the plans and conform to the requirements of AASHTO M 199. Concrete shall have a minimum 28 day compressive strength of 4,000 psi. The air entrainment in the concrete shall be 6 percent plus or minus 2 percent. Pipe openings shall be formed, drilled or neatly cut and be approved by the ENGINEER.

9. Concrete headwalls are included under Section SC – Structural Concrete of these Specifications.

10. Ductile iron frames, grates, and lids shall be used on all structures that may be subject to truck or heavy equipment traffic. This includes all drainage structures within the paved areas of intermodal, bulk, or other transfer facilities, unless otherwise specified on the Plans or bid sheet. Frames, grates, and lids shall conform to the requirements of ASTM A536 and be rated for airport loading. All castings shall be true to pattern and free from cracks, gas holes, flaws and excessive shrinkage. Surfaces shall be free from burnt on sand and be reasonably smooth.

11. Sluice gates shall meet the following requirements:

    a. Sluice gates shall be self-contained with either a non-rising stem extension or a rising stem extension as shown on the plans. The cover (slide) and frame shall be of cast iron with machined seating faces. The cover (slide) shall be of the diameter shown on the plans and "flatback" for mounting to a headwall.

    b. The stem shall be cold finished steel with a diameter capable of withstanding twice the rated output of the operator at 40 pound pull. A rising stem shall be supported for its full length so that the L/r (r = stem radius) ratio of the stem does not exceed 200. The handwheel shall be of cast iron.

    c. The frame, cover (slide) and handwheel shall meet the requirements of ASTM A-126. The stem shall meet the requirements of ASTM A-108.

12. The CONTRACTOR shall unload material furnished by the COMPANY in railroad cars and stockpile the material in an orderly manner. Any loss, theft of, or damage to the material shall be the responsibility of the CONTRACTOR.

13. Materials furnished in railroad cars by the COMPANY shall be inspected, counted, with the count verified by the ENGINEER and accepted prior to unloading. The CONTRACTOR shall unload, store and stockpile the material in an orderly manner. Any loss of, theft of, or damage to the material shall be the responsibility of the CONTRACTOR. Any damage discovered during the unloading of the material shall promptly be brought to the attention of the ENGINEER.

14. Materials not used, damaged materials, or materials unloaded that are not intended for the project shall be reloaded into COMPANY provided railroad cars.

15. All materials crossing under or within 25 feet of tracks must be capable of handling Cooper E-80 loadings

B. Bituminous Coated Corrugated Metal Pipe (BCCMP) – BCCMP and pipe arches shall meet the following requirements:

1. Corrugated metal pipe shall be zinc-coated and conform to the requirements of ASTM A760, Type 1 pipe.

2. Corrugations shall be annular riveted with a profile of 2-2/3 inches x 1/2 inch unless otherwise specified.

3. Bituminous coating shall be applied to the inner and outer surfaces of the pipe and conform to the requirements of AASHTO M 190, Type A.

4. If specified on the Plans, a polymer protective coating may be substituted for the bituminous coating. Polymer-Coated Corrugated Metal Pipe (PCCMP) shall have a grade 250/250 polymer protective coating applied to the inner and outer surfaces of the pipes and conform to the requirements of AASHTO M 246.

5. Bituminous paved inverts, where specified on the plans, shall conform to AASHTO M190, Type C. They shall cover 25 percent of the bottom of pipe periphery for circular pipes and 40 percent of the bottom pipe periphery for pipe arches. Bituminous paved inverts shall be shop applied.

6. Coupling bands shall be one or two piece annular corrugated, made from galvanized steel and fully bituminous coated, with a minimum width of 24 inches. Bands may be one gage lighter than the pipe gage. Bands shall be made of steel sheets conforming to ASTM Specification A 525 and AASHTO Designation M 218. Dimple band couplers shall not be used.

7. Coupling bands shall be fastened using a minimum of three 1/2 inch diameter galvanized bolts. Culverts 48 inches and larger require 24 inch wide bands with a minimum of four 1/2 inch diameter rods and “silo” type lugs.

C. Reinforced Concrete Pipe (RCP) shall meet the following requirements:

1. RCP shall conform to the requirements of AASHTO M 170.

2. RCP installed under tracks or other heavy-loading areas must be ASTM C 76 – Class V. The minimum RCP under intermodal facilities or truck driving areas is ASTM C 76 – Class IV unless otherwise specified on the project Plans..

3. Joints shall consist of a tongue and groove or a bell and spigot design. Gasketed joints must conform to ASTM C76.

D. High Density Polyethylene (HDPE) – HDPE shall meet the following requirements:

1. HDPE pipe with a diameter of 12" – 60" shall conform to the requirements of ASTM F2306 and AASHTO M294, Type S pipe.

2. Manning's roughness coefficient "n" value in design shall be 0.012.

3. Pipe dimensions shall be as follows:

Nominal Diameter, In (mm)										
Pipe I.D. in (mm)	12 (300)	15 (375)	18 (450)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	54 (1350)	60 (1500)
Pipe O.D.* in (mm)	14.5 (368)	18 (457)	22 (559)	28 (711)	36 (914)	42 (1067)	48 (1219)	54 (1372)	61 (1549)	67 (1702)

**Pipe O.D. values are provided for reference purposed only, values stated for 12"-60" are ±1 inch*

Table 1: HDPE Pipe Size Requirements

4. Handle Cooper E-80 loading.

5. Except with the approval of the Project ENGINEER, all couplings shall be the bolted double wide split band couplers as shown in the standard drawing. The coupler shall be wrapped around the pipe end and installed with a minimum of four stainless steel bolts, nuts and washers through holes provided by the manufacturer and tightened securely around the pipe. If the plans or Project ENGINEER specifies the use of filter fabric, it shall follow NS Standard Specifications for Engineering Fabric (EF-6 Drainage Applications).

6. Dissimilar pipe connections shall be connected with a polyseal double wide repair coupler. Couplers shall consist of a mastic adhesive base layer, a cross-laminated polyethylene middle layer and a spun-bonded geotextile polypropylene cloth outer layer. Connections shall consist of 3 hose clamp straps for 12" - 24" pipe and 3 ratchet straps for 30" – 60" pipe.

7. If water tight connection is specified on the plans, fitting connection shall consist of a bell and spigot connection utilizing a welded bell and valley gasket. The joint shall meet the watertight requirements of ASTM D3212, and gaskets shall meet the requirements of ASTM F477. If jointing a fitting to standard inline bell/spigot pipe, the bell or spigot may need to be cut off to enable proper connection.

8. Fittings shall conform to ASTM D2321 and meet performance indicated above for fitting connections. Fitting structural performance shall be equal to pipe structural performance.

E. Smooth Wall Steel Pipe shall meet the following requirements:

1. Smooth steel pipe shall conform to the requirements of ASTM A 139, Grade B (No Hydro) and have a minimum yield strength of 35,000 psi.

2. The minimum wall thickness shall be as follows:

Nominal Size (Inches)	Minimum Wall Thickness (Inches)
24	0.500
30	0.500
36	0.500
42	0.625
48	0.625
54	0.750
60	0.875
66	0.875
72	1.000

Table 2: Smooth Wall Steel Pipe

3. Sections of smooth steel pipe shall be field welded with a full depth, single "V" groove (butt joint) weld.

F. Aluminized Steel Pipe shall meet the following requirements:

1. Aluminized steel pipe material shall be formed from aluminized sheets conforming to the requirements of ASTM A 819 and AASHTO M 274 and manufactured according to AASHTO M36. No other coating shall be required.

2. Corrugations shall be annular riveted with a profile of 2-2/3 inches x 1/2 inch unless otherwise specified.

3. Coupling bands shall be one piece annular corrugated, made from aluminized steel, 2 feet wide. Coupling bands shall be fastened using a minimum of 3 galvanized 1/2 inch diameter bolts. Pipes 48 inches in diameter and larger required 2 feet wide bands with 4 rods, 1/2 inch in diameter and "silo" type lugs.

G. PVC pipe shall meet the following requirements:

1. Use Schedule 80, Type 2, PVC pipes and fittings conforming to ASTM D 1785.

2. If specified on plans, underdrain perforation size and spacing shall conform to ASTM C 444, Type 1.

3. Pipe joints shall be solvent welded. Solvent and procedures shall conform to pipe manufacturer's recommendations.

4. Pipe fittings and joints shall be of equal strength and quality as straight PVC pipe.

H. Filter fabric for underdrains shall consist of a porous nonwoven fabric conforming to section EF – Engineering Fabric and Geogrid (Drainage Applications) of this specification. Filter fabric should weigh not less than 4 oz./SY.

DR-3 Pipe Installation – Open Cut Method

A. General

1. Pipe installation shall conform to the lines and grades as shown on the plans or as staked in the field by the ENGINEER.

2. For installation in excavated trenches, the width of the trench and bedding shall be 24 inches greater than the outside diameter of the pipe.

3. Excavated materials shall not be placed within 5 feet of the edge of the excavation.

4. Shoring shall be required for excavations deeper than 5 feet or side slopes shall be cut back a sufficient amount to prevent slides. The CONTRACTOR shall furnish shoring plan and calculations to the ENGINEER for review and approval 2 weeks prior to the expected start of the shoring installation.

5. In general, pipe installation shall begin at the downstream end of the pipe.

6. After the CONTRACTOR has properly de-watered the installation area(s), the ENGINEER shall inspect and approve the area(s) prior to the placement of any bedding material. Should the ENGINEER require an area to be undercut prior to placement of bedding material, the CONTRACTOR shall undercut the area in accordance with Section GR - Grading of these Specifications.

7. Bell or groove ends of rigid pipe and outside circumferential laps of corrugated metal pipe shall be placed facing upstream.

8. Pipe ends that are temporarily not banded and ends of pipe runs shall be protected from filling by bedding or loose backfill material.

9. If headwalls are to be placed, the end of the pipe shall be installed flush with the outside face of the headwall. Connection of a pipe to an existing headwall shall be as shown on the plans.

10. At locations approved by the ENGINEER and Division Superintendent, the CONTRACTOR shall install pipe(s) under existing track(s) by the open cut method. Such installation shall be as follows, unless otherwise noted on Plans or directed by the ENGINEER:

    a. COMPANY forces shall perform all trackwork on existing tracks

    b. CONTRACTOR shall excavate the trench. Excavated materials shall not be placed on the track area. Cover shall be provided to prevent soil/debris

contamination of the existing ballast section. If ballast from the excavation is to be reused, it shall be stored separately to prevent contamination by fines.

c. Pipe and bedding material shall be placed in accordance with this section.

d. Trench shall be backfilled in accordance with this section to within 2 feet of the bottom of the tie. All backfill shall be NS Type B dense graded aggregate.

e. After trench is backfilled, the COMPANY shall re-install the tracks and ballast.

B. Bituminous Coated Corrugated Metal Pipe (BCCMP)

1. Paved BCCMP shall be laid so that the longitudinal centerline of the paved segment coincides with the flow line.

2. BCCMP with a diameter of 42 inches or larger shall be field strutted (if not manufacturer strutted). Ties and struts shall be removed by the CONTRACTOR upon completion of the embankment.

3. Where BCCMP has to be cut to achieve the proper length, such cutting shall be done with an abrasive saw so as to prevent damage to the pipe coating. Flame cutting shall not be permitted. Damage to the shop coating by this or any other work shall be field repaired by the CONTRACTOR by using asphalt paint. Repairs shall be at no cost to the COMPANY.

C. PVC Underdrains

1. Excavate in accordance with this section.

2. Install filter fabric in accordance with manufacturer's recommendations. Place initial filter bedding material and install pipe before placing remainder of filter material.

3. Close filter fabric to enclose filter material, and backfill with open-graded stone using AASHTO #57 gradation or as shown on Plans.

D. High Density Polyethylene Pipe (HDPE)

1. See drawings in Appendix A for information regarding HDPE pipe installation.

2. Installation shall conform to ASTM D2321 and meet joint performance indicated above for fitting connections. Fitting structural performance shall be equal to pipe structural performance.

3. Bedding material shall be placed and compacted under the haunches of the pipe to a minimum distance of 12" above the top of the pipe.

4. Minimum trench widths:

PIPE DIA.	MINIMUM TRENCH WIDTH	MINIMUM COVER	MAXIMUM COVER	
			CLASS I	CLASS II
12”	30”	2’	25’	20’
15”	34”	2’	25’	20’
18”	39”	2’	25’	20’
24”	48”	2’	25’	20’
30”	56”	3’	25’	15’
36”	64”	3’	25’	15’
42”	72”	4’	25’	15’
48”	80”	4’	25’	15’
54”	88”	4’	25’	15’
60”	96”	4’	25’	15’

Table 3: Minimum Trench Widths for HDPE Pipe

DR-4 Pipe Installation – Jack and Bore Method

A. The jack and bore method shall be applicable for installation of smooth wall steel pipe.

B. The CONTRACTOR shall submit to the ENGINEER a complete plan and schedule for pipe installation 2 weeks prior to the expected commencement of such work. The submission shall include complete details of the sheeting, shoring and bracing for the protection of the roadbed, materials and equipment pertinent to the operation. The CONTRACTOR shall not proceed with the pipe installation until he has received acceptance of the plan and schedule from the ENGINEER.

C. The COMPANY shall provide a flagman and a schedule of allowable work periods for the jack and bore operation in accordance with Section GI-General Instructions of these Specifications. Work shall stop when a train is passing. No claim by the CONTRACTOR against the COMPANY will be allowed for delay caused by the COMPANY’s train operations.

D. If the installation of the pipe is being conducted in an unsafe manner, as determined by the ENGINEER, CONTRACTOR shall be required to stop work and bulkhead the heading until an alternate procedure is proposed by the CONTRACTOR and accepted by the COMPANY.

E. The boring operation shall be progressed on a 24-hour basis without stoppage (except for adding lengths of pipe) until the leading edge of the pipe has reached the receiving pit. The installation shall be carried on without interruption, insofar as practicable, to prevent the pipe from becoming firmly set in the embankment.

F. The installation shall be carried on in such a manner that settlement on the ground surface above the pipe line shall be held to an absolute minimum.

G. The installation of the pipe line shall follow the heading and boring excavation as soon as possible.

H. End of pipe shall remain as close as practical to auger head and the distance shall not exceed 18 inches.

I. The over-cut by the cutting head shall not exceed the outside diameter of the pipe by more than 1/2 inch (13 mm). If voids should develop or if the bored hole diameter is greater than the outside diameter of the pipe by more than 1 inch, the voids shall be pressure grouted.

J. When boring and jacking pipe 36 inches and larger in diameter and the boring is halted within a distance less than 20 feet to the centerline of track, the heading shall be shored and braced if the track is active.

K. Any pipe damaged during the operation shall be removed and replaced by the CONTRACTOR at his expense.

L. The pits or trenches excavated to facilitate the pipe installation shall be backfilled immediately after the installation has been completed and in accordance with these Specifications.

DR-5 Joining Pipe

A. General

1. Connection of pipes made of dissimilar materials shall be by means of a concrete collar. The collar shall overlap each pipe by 2 feet and have a minimum thickness of 12 inches at any location around the pipes.

B. Joints for BCCMP shall meet the following requirements:

1. Sections of pipe shall be joined by using approved metal coupling bands.

2. Pipe and bands shall be free of debris, soil and rock before being joined.

3. Sections of pipe shall be positioned against or within 1 inch of each other before the band is closed.

4. When closing the band, the corrugations of the band and pipe should be aligned.

5. All bands are to be secured and fully bolted.

C. Joints for reinforced concrete pipe shall meet the following requirements:

1. Joints shall be made with cement mortar, rubber gaskets, or other approved sealers.

2. Pipe ends shall be fully entered and the inner surfaces shall be flush and even.

3. Mortar joints shall be made as follows:

   a. Pipe ends shall be thoroughly cleaned and wetted before the joint is made.

   b. Stiff mortar shall be applied to the lower half of the bell or groove of the pipe section already laid and to the upper half of the spigot or tongue of the section to be laid.

   c. After joining the 2 pipes flush and even, the inside of the joint shall be smooth with any excess material removed from the pipe.

4. Rubber ring gaskets or other approved sealers shall be installed in accordance with the manufacturers' recommendations.

D. Joints for HDPE pipe shall meet the following requirements:

1. Except with the approval of the Project ENGINEER, all couplings shall be the bolted double wide split band couplers as shown in the standard drawing. The coupler shall be wrapped around the pipe end and installed with a minimum of four stainless steel bolts, nuts and washers through holes provided by the manufacturer and tightened securely around the pipe. If the plans or Project ENGINEER specifies the use of filter fabric, the fabric shall comply with section EF – Engineering Fabric.

2. Dissimilar pipe connections shall be connected with a polyseal double wide repair coupler. Couplers shall consist of a mastic adhesive base layer, a cross-laminated polyethylene middle layer and a spun-bonded geotextile polypropylene cloth outer layer. Connections shall consist of 3 hose clamp straps for 12” - 24” pipe and 3 ratchet straps for 30” – 60” pipe.

3. If water tight connection is specified on the plans, fitting connection shall consist of a bell and spigot connection utilizing a welded bell and valley gasket. The joint shall meet the watertight requirements of ASTM D3212, and gaskets shall meet the requirements of ASTM F477. If jointing a fitting to standard inline bell/spigot pipe, the bell or spigot may need to be cut off to enable proper connection.

4. Fittings shall conform to ASTM D2321 and meet performance indicated above for fitting connections. Fitting structural performance shall be equal to pipe structural performance.

DR-6 Drop Inlet, Catch Basins and Manhole Installation

A. Drop inlet, catch basin and manhole installation shall conform to the lines and grades as shown on the plans or as staked in the field by the ENGINEER.

B. Corrugated metal pipe drop inlets, catch basins and manholes shall be installed as follows:

1. Excavation shall be in accordance with Section GR - Grading of these Specifications.

2. Bedding material shall be placed, spread and compacted a minimum of 12 inches under the structures. Bedding shall be placed and compacted around the drop inlets to the mid-point of the pipe branches.

3. Barrel risers shall be adjusted in the field to attain the proper grate/lid elevation using additional lengths of matching pipe banded to the barrel tops with 12 inch wide connecting bands.

4. A minimum of 4 inches of concrete shall be poured into the base of each structure as a base once the proper flow line has been achieved.

C. Precast Concrete structures shall be installed as follows:

1. Excavation shall be in accordance with Section GR - Grading of these Specifications.

2. Bedding material shall be placed, spread and compacted a minimum of 12 inches under the structures. Bedding shall be placed and compacted around the drop inlets to the mid-point of the pipe branches.

3. Precast concrete barrel risers shall be adjusted in the field to attain the proper grate/lid elevation.

4. Pipe sections shall be flush on the inside of the structure wall. Masonry shall fit neatly and tightly around the pipe.

D. HDPE structures shall be installed as follows:

1. Excavation shall be in accordance with Section GR - Grading of these Specifications.

2. Bedding material shall be placed, spread and compacted a minimum of 12 inches under the structures. Bedding shall be placed and compacted around the drop inlets to the mid-point of the pipe branches.

3. HDPE riser sections shall be adjusted to meet the proposed inlet elevation as shown on Plans. Adjust risers per manufacturer's recommendations.

4. HDPE pipes shall be connected to structures using the methods specified in this section.

E. Frames for castings and bearing plates shall be set in full mortar beds and secured as shown on the plans. The mortar shall consist of one part Type 1 Portland Cement, 2 parts and a sufficient quantity of water to make the mortar workable. Castings shall be set to finished pavement elevations.

F. Any damage to the corrugated metal structure and the bituminous coating or the precast concrete structure caused by improper handling or backfilling shall be repaired by the CONTRACTOR at no expense to the COMPANY.

DR-7 Inspection

A. Pipes shall be inspected and approved by the ENGINEER before any backfill is placed.

B. Any pipe found to be vertically or horizontally out of alignment, deformed, or structurally damaged shall be taken up and re-laid at no expense to the COMPANY.

C. Any damage to pipe coatings must be repaired at no cost to the COMPANY.

DR-8 Backfill

A. General

1. After pipes and structures have been installed, inspected and approved by the ENGINEER, the trench/excavation shall be backfilled using suitable materials excavated from the trench or structure excavation, from the roadbed excavation, or borrow materials. Backfill material shall be approved by the ENGINEER.

2. Drop inlets between tracks shall be backfilled with bedding material.

3. Compaction shall be to a density of not less than 95% in accordance with AASHTO T 99.

4. All pipes, after being backfilled, shall be protected by a minimum of 2 feet cover of fill before heavy equipment is permitted to cross during the construction of the roadbed.

5. Bedding and select backfill material shall be placed as follows:

   a. Bedding material shall extend the full length and width of the trench. The compacted depth of bedding material under the pipe shall not be less than 12 inches unless directed by the Project ENGINEER or shown differently on the plans.

   b. Bedding and select backfill shall be compacted to a density of not less than 95 percent in accordance with AASHTO T 99. Select backfill shall be placed alongside the pipe in uniform layers and compacted.

   c. When vibratory compaction equipment is used in conjunction with other methods of compaction, the compacted depth of a single layer of bedding material shall not exceed 6 inches (6-9 inches loose). When no vibratory compaction equipment is used, the maximum compacted thickness of one layer shall not exceed 3 inches (3-6 inches loose).

   d. If a hand tamper is used, it shall weigh not less than 20 pounds and have a tamping face not less than 6 inches x 6 inches.

6. Backfill under proposed track shall be as follows:

    a. After pipes and structures have been installed, inspected and approved by the ENGINEER, the trench/excavation shall backfilled using suitable materials excavated from the trench or structure excavation, from the roadbed excavation, or borrow material.

    b. Backfill material shall be placed alongside the pipe in uniform layers and fully compacted. When vibratory equipment is used in conjunction with other methods of compaction, the compacted depth of a single layer of bedding shall not exceed 6 inches (6-9 inches loose). When no vibratory compaction is used, the maximum compacted thickness of one layer shall not exceed 3 inches (3-6 inches loose). If a hand tamper is used, it shall weigh no less than 20 pounds and have a tamping face not less than 6 inches x 6 inches.

    c. Compaction shall be to a density of not less than 95 percent in accordance with AASHTO T 99.

    d. All pipes, after being backfilled, shall be protected by a minimum of 2 feet cover of fill before heavy equipment is permitted to cross during the construction of the roadbed.

7. Pipe trenches under existing tracks shall be backfilled with NS Type B dense graded aggregate to within 2 feet of the bottom of tie.

B. HDPE Pipe

1. Bedding material shall be placed and compacted under the haunches of the pipe extending from the bottom of pipe up to a minimum distance equal to 12”above the top of pipe.

2. Minimum cover from bottom of tie to top of pipe for 12” – 24” (100 to 600 mm) diameters shall be 2’ (0.6 m), for 30” – 36” (750 to 900 mm) diameters shall be 3’ (0.9 m) and for 42”- 60” (1050 to 1500 mm) diameters the minimum cover shall be 4’ (1.2 m) in single run applications. Minimum fill heights shall be verified by the manufacturer per design loads.

3. Maximum cover from bottom of tie to top of pipe with diameters 24” and less shall be 25’ when pipe is installed with Class I compacted backfill as pipe embedment material, and 20’ if Class II (minimum 95% SPD) backfill is used as pipe embedment material. Maximum cover from bottom of tie to top of pipe for 30” – 60” (750 to 1500 mm) shall be 25’ when pipe is installed with Class I compacted backfill as pipe embedment material, and 15’ if Class II (minimum 95% SPD) backfill is used as pipe embedment for overburden material. Maximum fill heights shall be verified by the manufacturer per design loads. Maximum fill heights are based on no hydro-static pressure. If hydro-static pressure is present, the manufacturer must verify maximum cover.

DR-9 Precast Box Culverts

A. Except as otherwise specified below or on the Plans, the current American Railway Engineering and Maintenance Association (AREMA) Manual for Railway Engineering (Specifications), Chapter 8 - Concrete Structures and Foundations; Parts 2 – Reinforced Concrete Design, and 16 – Design & Construction of Reinforced Concrete Box Culverts, shall apply to all work.

B. Components shall be manufactured as specified in AREMA Specifications – Chapter 8, Section 16.2.6.

C. Design and submittal requirements:

1. The manufacturer shall design the box sections for Coopers E-80 Rail Loading, plus Impact, as shown in AREMA Figure 16-1. All other design loads and design factors shall be as specified in AREMA Chapter 8; Parts 2 & 16 and as specified on the Plans.

2. The CONTRACTOR shall furnish the following to the ENGINEER for approval, and must not start fabrication until written approval is received:

a. A complete set of design calculations showing maximum design shear and moments and actual stresses. Calculations must be stamped by a Registered Professional Engineer.

b. A set of shop drawings showing reinforcement details and dimensions of typical box section. Drawings shall also indicate the locations for the required couplers, and must be stamped by the Registered Professional Engineer that stamps the Calculations.

c. A minimum of four (4) Mechanical Couplers shall be used at each joint. Opening may not be reduced from opening shown on the plan. Couplers must be recessed on inside of box. In lieu of couplers, embedded post-tensioning rods may be employed.

d. A set of final approved shop plans.

e. A set of installation recommendations or specifications.

D. Concrete strength, proportions, and mixes:

1. Cement, unless otherwise specified, shall conform to the following:

a. For standard concrete, cement shall be Portland Cement, Type I or Type IA, conforming to the requirements of ASTM Designation C150.

b. For high-early strength concrete, cement shall be Type III, or Type IIIA, conforming to the requirements of ASTM Designation C150.

2. Minimum design compressive strength, at 28 days, shall be 5000 psi, minimum, unless indicated otherwise on the Plans. A higher design compressive strength may be utilized, as required, to meet the required design specifications.

    a. Minimum cement content, for 5,000 psi concrete, shall be 7.00 Bags/CY (660 LBS/CY).

3. Fly Ash, and any other admixtures, approved by the Engineer, shall be in addition to the minimum cement content indicated above, not in lieu of cement.

4. Nominal size of coarse aggregate shall be 1" - No. 4 (Size 57). See AREMA Table 1.3.3

5. Concrete shall be air-entrained by the use of an air entraining admixture conforming to requirements of ASTM Designation, C260, or by the use of air-entraining Portland cement meeting the requirements of ASTM Specification

6. Admixtures, except air-entraining agents, used to alter the normal properties of concrete for either densifying, dispersing, retarding, accelerating, plasticizing, coloring, or waterproofing, shall be used only upon written permission of the Engineer.

7. Testing: Compression tests will be required as specified in the AREMA Manual, Chapter 8, Part 1. The Fabricator shall furnish all test materials and test cylinder molds, shall perform all work to make and cure the test cylinders, and after proper curing, shall deliver the test cylinders to an independent testing laboratory where they shall be tested at the Fabricator's expense. The test results shall be furnished directly to the Engineer in writing, by the testing laboratory, on a standard testing report form. Not less than four test cylinders shall be made for each twenty cubic yards or fraction thereof, of cast-in-place concrete. One pair of cylinders shall be tested at 7 days and the second pair at 28 days.

E. Reinforcing steel:

1. Reinforcing steel bars shall be intermediate grade, new billet steel, conforming to ASTM Designation A615, Grade 60. Reinforcing bars shall be bent cold in the shop or in the field around a pin not less than 6 times the diameter of the bar. Reinforcing partially embedded in concrete or in mortar in dowel holes shall not be field bent, except as permitted by the Engineer.

2. Welded wire mesh shall conform to ASTM Designations A185 or A497.

F. Other materials:

1. All hardware for couplers, sleeves, anchor bolts, inserts and other purposes shall be hot-dipped galvanized or stainless steel as specified in the AREMA Specifications – chapter 8, section 16.2.6.

2. Gasket material shall be as specified in the AREMA Specifications – chapter 8, section 16.2.7.

3. Fabricator shall provide all couplers, gaskets, filter fabrics and other hardware needed for field assembly.

DR-10 Measurement and Payment

A. Measurement

1. Drainage structures, i.e. manholes, catch basins, drop inlets, sluice gates, metal pipe flared end sections, etc., shall be measured by the number of each type installed.

2. Pipe shall be measured by the linear foot in place, the measurement being made along the centerline of the pipe installed, for each type and size of pipe installed. The portion of the pipe extending through to the inside face of the headwalls of all types and precast concrete structures shall be included in the measurement.

3. Underdrains shall be measured by the linear foot in place, as measured along the centerline of pipe installed for each type and size of pipe.

4. There shall be no separate measurements for trenching, unloading and stockpiling of COMPANY furnished materials, structure excavation, bedding material, or concrete used for construction of concrete collars for connecting pipes of dissimilar materials and corrugated metal structure foundations.

B. Payment

1. Payment for drainage structures, including manholes, catch basins, drop inlets, sluice gates, and flared end sections, will be made at the Contract unit bid price per each type of structure installed by material, which price shall include all necessary material, labor and equipment.

2. Payment for pipe installed will be made at the Contract unit bid price per foot for the type and size of pipe installed, which price shall include all necessary material, labor and equipment.

3. Payment for perforated pipes or underdrains will be made at the Contract unit bid price per foot for the type and size of perforated pipes or underdrains installed. The price shall include all necessary material, labor and equipment, including filter fabric and filter stone.

4. Payment for stone or specialty backfill, when included on the bid sheet as a separate item, shall be paid at the Contract unit price per ton based on the Contract documents and section GA - Graded Aggregate. The price shall include all necessary material, labor, and equipment.

5. No separate payment shall be made for the following:

a. Trenching.

b. Structure excavation.

c. Bedding material.

d. Backfill when using native soils.

e. Unloading and storing of COMPANY furnished materials.

f. Connecting bands.

g. BCCMP or precast concrete risers required for structure height adjustment.

h. Pipe joining material.

i. Grouting.

j. Gates/lids.

k. Disposal of unsuitable material.

l. Construction of concrete collars for connecting pipes of dissimilar materials.

m. Concrete for corrugated metal structure foundations.

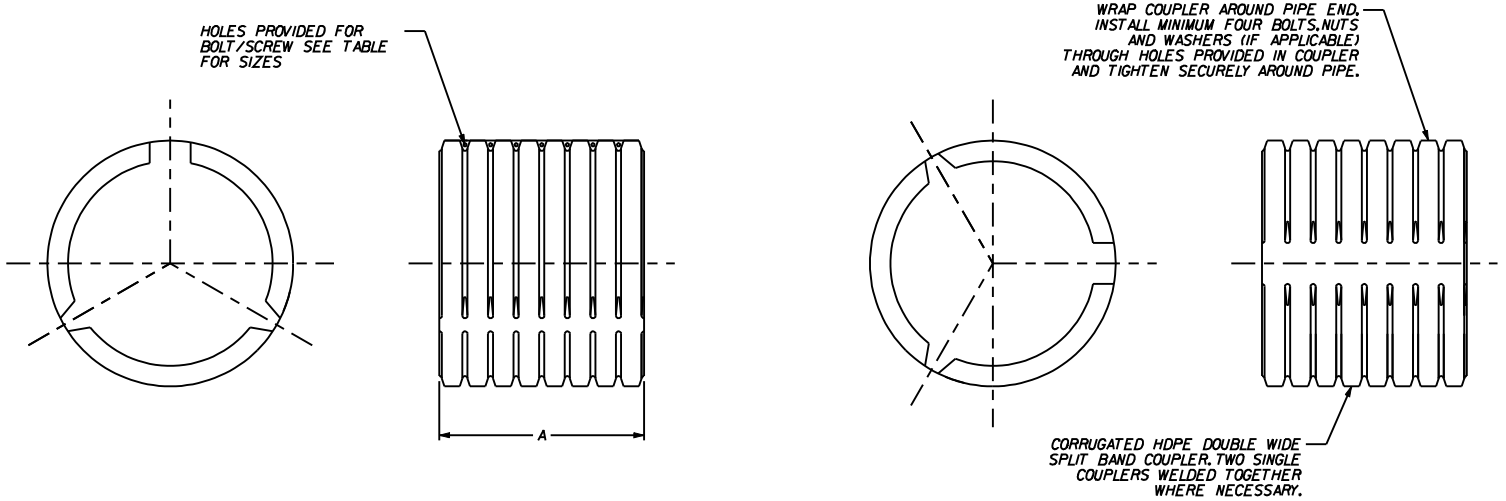
n. Removal of silt or other debris from pipes, catch basins or other drainage structures.

o. Removal and replacement of existing pavement. Pavement shall be replaced in-kind per NS specifications.

APPENDIX A – Drawings

A. Drawing DR-HDPE-01: HDPE Pipe Coupler

12" - 60" DIAMETER COUPLERS



COUPLER DIAMETER	A	BOLT/SCREW TYPE**
12" (300 mm)	16" (400 mm)	B
15" (375 mm)	21" (533 mm)	C
18" (450 mm)	21" (533 mm)	C
24" (600 mm)	26" (648 mm)	C
30" (750 mm)	33" (838 mm)	D
36" (900 mm)	36" (900 mm)	D
*42" (1050 mm)	42" (1054 mm)	D
*48" (1200 mm)	42" (1067 mm)	D
*60" (1500 mm)	48" (1220 mm)	E/F

* TWO PIECE COUPLERS WILL REQUIRE TWICE AS MANY BOLTS
**BOLTS SHALL BE STAINLESS STEEL

BOLT/SCREW TYPE:
B - 3/16" DIA., 3" LONG NO WASHER REQUIRED
C - 1/4" DIA., 4" LONG NO WASHER REQUIRED
D - 5/16" DIA., 6 1/2" LONG WITH 5/16" WASHERS
E - 1/4" DIA., 6 1/2" LONG WITH 1/4" WASHERS
F - DRILL 5/16" HOLE IN COUPLER, USE 5/16" DIA., 6 1/2" LONG WITH 5/16" WASHERS

BOLT/MACHINE SCREWS SHALL BE CAP HEAD OR DOMED PHILLIPS HEAD. BOLTS/MACHINE SCREWS SHALL BE THREADED AS MUCH AS POSSIBLE.

SCALE: NTS

DO NOT SCALE THIS DRAWING FOR DIMENSIONS NOT GIVEN

REV	BY	DATE	DESCRIPTION

NORFOLK SOUTHERN

NORFOLK SOUTHERN RAILWAY COMPANY
OWNING COMPANY

SYSTEMWIDE
OPERATING DIVISION
OFFICE OF THE CHIEF ENGINEER - DESIGN AND CONSTRUCTION - ATLANTA, GA.

LOCATION: SYSTEMWIDE

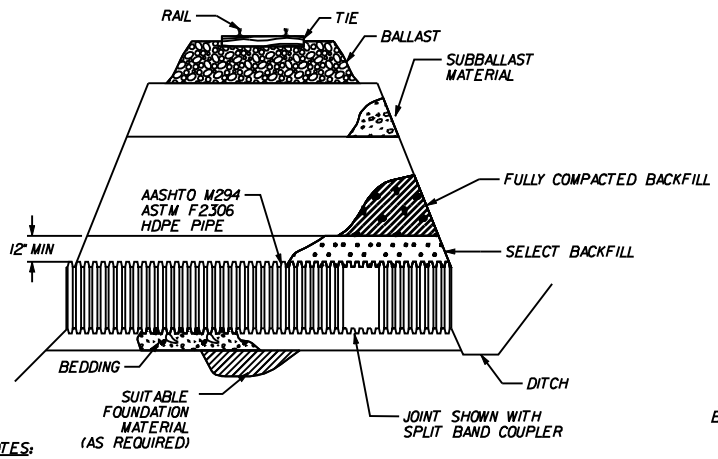
TITLE: HDPE PIPE COUPLER DETAIL

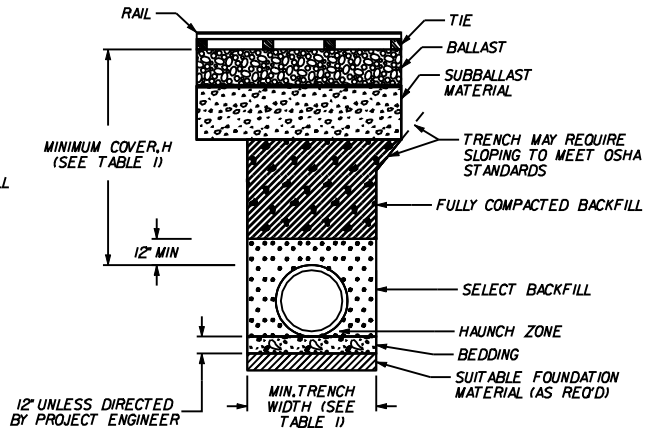
DGN	PID No.	VRN	MILE POST
DWN	FILE No.		DRAWING NUMBER: DR-HDPE-01
CHK	DATE: OCTOBER 19, 2010		

CADD FILE:

B. Drawing DR-HDPE-02: HDPE Pipe Trenches Under Proposed Tracks

UNDER PROPOSED TRACK





BALLAST

SUBBALLAST

BACKFILL

SELECT BACKFILL

BEDDING

FOUNDATION

NOTES:

1. ALL PIPE SYSTEMS SHALL BE INSTALLED IN ACCORDANCE WITH ASTM D2321, "STANDARD PRACTICE FOR UNDERGROUND INSTALLATION OF THERMOPLASTIC PIPE FOR SEWERS AND OTHER GRAVITY FLOW APPLICATIONS", LATEST EDITION

2. MEASURES SHOULD BE TAKEN TO PREVENT MIGRATION OF NATIVE FINES INTO OPEN GRADED MATERIAL.

3. FOUNDATION: WHERE THE TRENCH BOTTOM IS UNSTABLE, THE CONTRACTOR SHALL EXCAVATE UNSUITABLE MATERIAL TO THE REQUIRED DEPTH AND REPLACE WITH SUITABLE MATERIAL AS SPECIFIED BY THE DESIGN ENGINEER. DEPTH OF FOUNDATION IMPROVEMENT MAY BE REDUCED BY USE OF GEOTEXTILE FABRIC AND GRID. REQUIRED TRENCH WIDTH MAY INCREASE WHEN FOUNDATION MATERIALS ARE MODIFIED.

4. BEDDING: BEDDING MATERIAL SHALL CONFORM TO CATEGORY B DENSE GRADED AGGREGATE IN ACCORDANCE WITH SECTION GA - GRADED AGGREGATE OF THE NS STANDARD SPECIFICATIONS UNLESS STATED OTHERWISE BY THE DESIGN ENGINEER OR PLANS. MINIMUM BEDDING THICKNESS SHALL NOT BE LESS THAN 12 INCHES. THE MIDDLE THIRD OF THE BEDDING SHALL BE LOOSE AND UNIFORM IN DEPTH AND CONSISTENCY. AFTER PIPE IS IN PLACE, COMPACT BEDDING TO SELECT BACKFILL STANDARDS. BEDDING SHALL BE COMPACTED TO A DENSITY OF NOT LESS THAN 95 PERCENT IN ACCORDANCE WITH AASHTO T 99.

5. SELECT BACKFILL: SELECT BACKFILL MATERIAL SHALL CONFORM TO CATEGORY B DENSE GRADED AGGREGATE IN ACCORDANCE WITH SECTION GA - GRADED AGGREGATE OF THE NS STANDARD SPECIFICATIONS UNLESS STATED OTHERWISE BY THE DESIGN ENGINEER OR PLANS. MINIMUM COMPACTION SHALL BE TO A DENSITY OF NOT LESS THAN 95 PERCENT IN ACCORDANCE WITH AASHTO T 99. BACKFILL MATERIAL SHALL BE PLACED ALONGSIDE THE PIPE IN UNIFORM LAYERS AND COMPACTED. WHEN VIBRATORY COMPACTION EQUIPMENT IS USED IN CONJUNCTION WITH OTHER METHODS OF COMPACTION, THE COMPACTED DEPTH OF A SINGLE LAYER OF BEDDING MATERIAL SHALL NOT EXCEED 6 INCHES (6-9 INCHES LOOSE). WHEN NO VIBRATORY COMPACTION EQUIPMENT IS USED, THE MAXIMUM COMPACTED THICKNESS OF ONE LAYER SHALL NOT EXCEED 3 INCHES (3-6 INCHES LOOSE). IF A HAND TAMPER IS USED, IT SHALL WEIGH NOT LESS THAN 20 POUNDS AND HAVE A TAMPING FACE NOT LESS THAN 6 INCHES X 6 INCHES.

6. THE CONTRACTOR SHOULD PROVIDE DOCUMENTATION FOR MATERIAL SPECIFICATIONS TO DESIGN ENGINEER, WHERE BACKFILL VERIFICATION IS NOT PROVIDED OR WHERE BACKFILL MAY BECOME SATURATED AFTER PLACEMENT, ONLY ASTM CLASS I OR II (CLEAN) BEDDING AND BACKFILL SHOULD BE USED.

7. BEDDING MATERIAL SHALL BE PLACED AND COMPACTED UNDER THE HAUNCHES OF THE PIPE EXTENDING FROM THE BOTTOM OF PIPE UP TO A DISTANCE EQUAL TO 1/3 OF THE PIPE'S DIAMETER UNLESS OTHERWISE DIRECTED BY THE ENGINEER.

TABLE 1
RECOMMENDED MINIMUM TRENCH WIDTHS, MIN. COVER [1,2,3,4,5] AND MAX. COVER [1,2,3,4,5]

PIPE DIA.	MIN. TRENCH WIDTH	MINIMUM COVER	MAX. COVER CLASS I	MAX. COVER CLASS II
12"	30"	2'	25'	20'
15"	34"	2'	25'	20'
18"	39"	2'	25'	20'
24"	48"	2'	25'	20'
30"	56"	3'	25'	15'
36"	64"	3'	25'	15'
42"	72"	4'	25'	15'
48"	80"	4'	25'	15'
54"	88"	4'	25'	15'
60"	96"	4'	25'	15'

1. COVER IS MEASURED FROM TOP OF PIPE TO BOTTOM OF RAILWAY TIE.
2. LOADS GREATER THAN E-80 LOAD MAY REQUIRE ADDITIONAL COVER.
3. MINIMUM COVER MAY BE INCREASED TO PREVENT PIPE DAMAGE DUE TO ROUTINE TRACK MAINTENANCE.
4. MANUFACTURER NEEDS TO VERIFY ALLOWABLE FILL HEIGHTS PER DESIGN LOADS
5. FILL HEIGHT CALCULATIONS DO NOT TAKE IN TO CONSIDERATION GROUND WATER. WHERE GROUND WATER IS ENCOUNTERED HAVE THE MANUFACTURER VERIFY FILL HEIGHTS.

SCALE: NTS

DO NOT SCALE THIS DRAWING FOR DIMENSIONS NOT GIVEN

REV	BY	DATE	DESCRIPTION

NORFOLK SOUTHERN

NORFOLK SOUTHERN RAILWAY COMPANY
OWNING COMPANY

SYSTEMWIDE
OPERATING DIVISION
OFFICE OF THE CHIEF ENGINEER - DESIGN AND CONSTRUCTION - ATLANTA, GA.

LOCATION: SYSTEMWIDE

TITLE: HDPE PIPE TYPICAL TRENCH DETAIL
PROPOSED TRACK APPLICATIONS

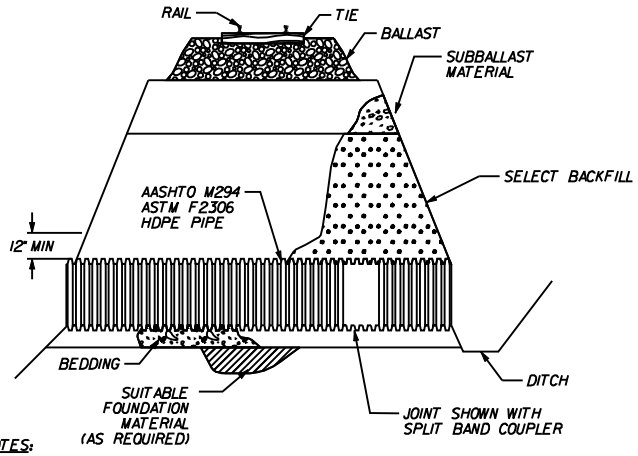
DGN	PID No.	VRN	MILE POST
DWN	FILE No.		DRAWING NUMBER: DR-HDPE-2
CHK	DATE: OCTOBER 19, 2010		

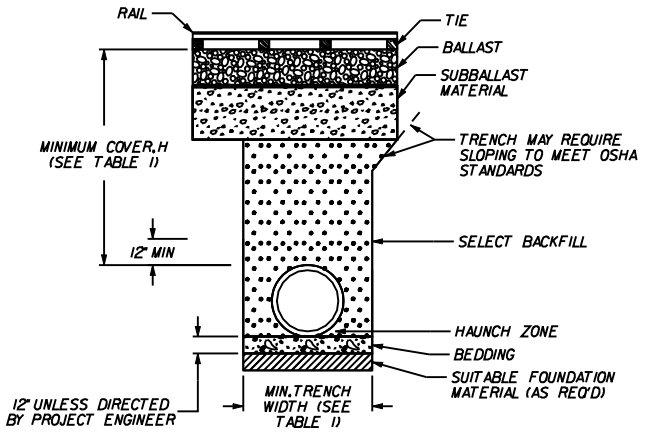
CADD FILE:

C. Drawing DR-HDPE-03: HDPE Pipe Trenches Under Existing Tracks

END OF SECTION

UNDER EXISTING TRACK





LEGEND

- BALLAST
- SUBBALLAST
- SELECT BACKFILL
- BEDDING
- FOUNDATION

NOTES:

1. ALL PIPE SYSTEMS SHALL BE INSTALLED IN ACCORDANCE WITH ASTM D2321, "STANDARD PRACTICE FOR UNDERGROUND INSTALLATION OF THERMOPLASTIC PIPE FOR SEWERS AND OTHER GRAVITY FLOW APPLICATIONS", LATEST EDITION

2. MEASURES SHOULD BE TAKEN TO PREVENT MIGRATION OF NATIVE FINES INTO OPEN GRADED MATERIAL.

3. FOUNDATION: WHERE THE TRENCH BOTTOM IS UNSTABLE, THE CONTRACTOR SHALL EXCAVATE UNSUITABLE MATERIAL TO THE REQUIRED DEPTH AND REPLACE WITH SUITABLE MATERIAL AS SPECIFIED BY THE DESIGN ENGINEER. DEPTH OF FOUNDATION IMPROVEMENT MAY BE REDUCED BY USE OF GEOTEXTILE FABRIC AND GRID. REQUIRED TRENCH WIDTH MAY INCREASE WHEN FOUNDATION MATERIALS ARE MODIFIED.

4. BEDDING: BEDDING MATERIAL SHALL CONFORM TO CATEGORY B DENSE GRADED AGGREGATE IN ACCORDANCE WITH SECTION GA - GRADED AGGREGATE OF THE NS STANDARD SPECIFICATIONS UNLESS STATED OTHERWISE BY THE DESIGN ENGINEER OR PLANS. MINIMUM BEDDING THICKNESS SHALL NOT BE LESS THAN 12 INCHES. THE MIDDLE THIRD OF THE BEDDING SHALL BE LOOSE AND UNIFORM IN DEPTH AND CONSISTENCY. AFTER PIPE IS IN PLACE, COMPACT BEDDING TO SELECT BACKFILL STANDARDS. BEDDING SHALL BE COMPACTED TO A DENSITY OF NOT LESS THAN 95 PERCENT IN ACCORDANCE WITH AASHTO T 99.

5. SELECT BACKFILL: SELECT BACKFILL MATERIAL SHALL CONFORM TO CATEGORY B DENSE GRADED AGGREGATE IN ACCORDANCE WITH SECTION GA - GRADED AGGREGATE OF THE NS STANDARD SPECIFICATIONS UNLESS STATED OTHERWISE BY THE DESIGN ENGINEER OR PLANS. MINIMUM COMPACTION SHALL BE TO A DENSITY OF NOT LESS THAN 95 PERCENT IN ACCORDANCE WITH AASHTO T 99. BACKFILL MATERIAL SHALL BE PLACED ALONGSIDE THE PIPE IN UNIFORM LAYERS AND COMPACTED. WHEN VIBRATORY COMPACTION EQUIPMENT IS USED IN CONJUNCTION WITH OTHER METHODS OF COMPACTION, THE COMPACTED DEPTH OF A SINGLE LAYER OF BEDDING MATERIAL SHALL NOT EXCEED 6 INCHES (6-9 INCHES LOOSE). WHEN NO VIBRATORY COMPACTION EQUIPMENT IS USED, THE MAXIMUM COMPACTED THICKNESS OF ONE LAYER SHALL NOT EXCEED 3 INCHES (3-6 INCHES LOOSE). IF A HAND TAMPER IS USED, IT SHALL WEIGH NOT LESS THAN 20 POUNDS AND HAVE A TAMPING FACE NOT LESS THAN 6 INCHES X 6 INCHES.

6. THE CONTRACTOR SHOULD PROVIDE DOCUMENTATION FOR MATERIAL SPECIFICATIONS TO DESIGN ENGINEER, WHERE BACKFILL VERIFICATION IS NOT PROVIDED OR WHERE BACKFILL MAY BECOME SATURATED AFTER PLACEMENT, ONLY ASTM CLASS I OR II (CLEAN) BEDDING AND BACKFILL SHOULD BE USED.

7. BEDDING MATERIAL SHALL BE PLACED AND COMPACTED UNDER THE HAUNCHES OF THE PIPE EXTENDING FROM THE BOTTOM OF PIPE UP TO A DISTANCE EQUAL TO 1/3 OF THE PIPE'S DIAMETER UNLESS OTHERWISE DIRECTED BY THE ENGINEER.

TABLE I
RECOMMENDED MINIMUM TRENCH WIDTHS, MIN. COVER [1,2,3,4,5] AND MAX. COVER [1,2,3,4,5]

PIPE DIA.	MIN. TRENCH WIDTH	MINIMUM COVER	MAX. COVER CLASS I	MAX. COVER CLASS II
12"	30"	2'	25'	20'
15"	34"	2'	25'	20'
18"	39"	2'	25'	20'
24"	48"	2'	25'	20'
30"	56"	3'	25'	15'
36"	64"	3'	25'	15'
42"	72"	4'	25'	15'
48"	80"	4'	25'	15'
54"	88"	4'	25'	15'
60"	96"	4'	25'	15'

1. COVER IS MEASURED FROM TOP OF PIPE TO BOTTOM OF RAILWAY TIE.
2. LOADS GREATER THAN E-80 LOAD MAY REQUIRE ADDITIONAL COVER.
3. MINIMUM COVER MAY BE INCREASED TO PREVENT PIPE DAMAGE DUE TO ROUTINE TRACK MAINTENANCE.
4. MANUFACTURER NEEDS TO VERIFY ALLOWABLE FILL HEIGHTS PER DESIGN LOADS
5. FILL HEIGHT CALCULATIONS DO NOT TAKE IN TO CONSIDERATION GROUND WATER. WHERE GROUND WATER IS ENCOUNTERED HAVE THE MANUFACTURER VERIFY FILL HEIGHTS.

SCALE: NTS

DO NOT SCALE THIS DRAWING FOR DIMENSIONS NOT GIVEN

REV	BY	DATE	DESCRIPTION

NORFOLK SOUTHERN

NORFOLK SOUTHERN RAILWAY COMPANY
OWNING COMPANY

SYSTEMWIDE
OPERATING DIVISION
OFFICE OF THE CHIEF ENGINEER - DESIGN AND CONSTRUCTION - ATLANTA, GA.

LOCATION: SYSTEMWIDE

TITLE: HDPE PIPE TYPICAL TRENCH DETAIL
EXISTING TRACK APPLICATIONS

DGN	PID No.	VRN	MILE POST
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CADD FILE:

Section EF – Engineering Fabric and Geogrids

EF-1 Description

The Work shall consist of furnishing and installing Engineering Fabric in accordance with these Specifications and the plans or as directed by the ENGINEER.

EF-2 Use Categories

A. Five divisions of Engineering fabrics and geogrids are specified:

1. Separation Applications including but not limited to installation under track, turnouts, rail and highway crossings, tunnels, roadways and parking facilities.

2. Paving Fabric Applications including new and overlay installation.

3. Erosion Control Applications, including slope matting, riprap underlayment, and silt fence fabric, related to erosion control and slope stability. Silt fence installation covered in Section ES – Erosion and Sediment Control.

4. Drainage Applications including but not limited to pavement drains, interceptor drains, wall drains, recharge basins and relief wells.

5. Geogrid Applications including base/subbase reinforcement, subgrade reinforcement, and pavement reinforcement.

EF-3 Compliance and Sampling Requirements

A. A competent laboratory must be maintained by the producer of the geotextiles and geogrids at the point of manufacture to insure quality control in accordance with ASTM testing procedures. That laboratory shall maintain records of its quality control results and provide said results to the ENGINEER upon request.

B. The certification shall be based on average roll minimum values and shall include:

1. Name of manufacturer.

2. Chemical composition.

3. Product description.

4. Statement of compliance to specification requirements.

5. Signature of legally authorized official attesting to the information required.

6. Purchaser.

7. Manufacturer's installation instructions, general recommendations, and data sheets.

C. The COMPANY may, at its expense, take a fabric or geogrid segment from every 20th roll or at an interval specified by the ENGINEER in the field and test segment at an independent competent laboratory to indicate compliance with these Specifications.

D. The ENGINEER or ENGINEER's representative may randomly inspect geogrids or fabrics before, during, and after (using test pits) installation.

E. Repairs:

1. Any roll of geogrid or fabric damaged before, during, or after installation shall be replaced by the CONTRACTOR at no additional cost to the COMPANY.

2. CONTRACTOR must repair any damaged or defective geogrid or fabric. Repairs shall extend 3 feet outside of the affected area in all directions.

EF-4 Separation Applications

A. Description

This Work shall consist of furnishing and placing a geotextile for use as a permeable separator to prevent inter-mixing of dissimilar materials such as: subgrades and surfaced or unsurfaced pavement materials; and foundations and select fill materials. The geotextile shall be designed to allow passage of water while retaining in-situ soil. This specification does not address geotextiles to be used for reinforcement.

B. Material

1. The geotextile shall be a nonwoven, needle punched product comprised of continuous or staple polyester or polypropylene filaments.

2. The geotextile shall be inert to commonly encountered chemicals, hydrocarbons and mildew. The geotextile shall be resistant to ultraviolet light, rot, insects, rodents and conform to the properties in the Table 1 entitled "Specific Physical Properties of Geotextiles".

3. Categories A, B & C shall be used as usage application selections and will be noted on the plans and in these Specifications.

4. The average roll minimum value (weakest principle direction) for strength properties of any roll tested from the manufacturing lot or lots or particular shipment shall be in excess of the average roll minimum value (weakest principle direction) stipulated.

5. The geotextile shall be tinted or otherwise treated to prevent the occurrence of snowblindness of handling personnel.

6. The geotextile shall be resistant to abrasion from the movement of adjacent roadbed material and of aggregate.

7. The geotextile shall be provided in rolls wrapped with protective covering. A tag or other method of identification shall be attached to each wrapped roll of fabric indicating the following:

    a. Manufacturer's name and address.

    b. Date of manufacture of fabric.

    c. Manufacturer's order number.

    d. Number or symbol of manufacturer's production run.

    e. Customer order number.

    f. Weight per sq. yd. of fabric.

    g. Width of roll.

    h. Length of roll.

8. Each roll of fabric shall be wrapped individually and the protective covering shall be adequate for long or short term storage.

C. Installation

1. Rolls shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. At no time shall the geotextile fabric be exposed to ultraviolet light for a period exceeding 14 days. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover.

2. In foundation applications the installation area shall be prepared by clearing all debris or obstructions which may damage the geotextile. Trees and large bushes should be cut at ground level. In most cases, all native vegetation, roots and topsoil must be removed from the roadway subgrade prior to geotextile placement. See Section CG - Clearing and Grubbing of these Specifications.

3. In roadway, rail and parking applications the subgrade areas shall be prepared to the proper lines and grade in accordance with Section GR - Grading of these Specifications prior to geotextile installation.

4. The geotextile shall be unrolled as smoothly as possible on the prepared subgrade in the direction of construction traffic. Geotextile rolls shall be overlapped in the direction of the subbase placement. The geotextile shall be overlapped a minimum of 12 inches for separation applications.

5. Damaged geotextiles, as identified by the ENGINEER, shall be repaired immediately. The damaged area plus an additional three feet around the damaged area shall be

cleared of all fill material. A geotextile patch extending three feet beyond the perimeter of the damage shall be constructed as directed by the ENGINEER. Sewing of a geotextile patch may be required over soft subgrades as directed by the ENGINEER. Damaged geotextile shall be repaired at no cost to the COMPANY. Sewing repair shall be in accordance with the manufacturer's recommendations.

6. COMPANY shall have the right to reject geotextile material, if in the opinion of the ENGINEER, damage or deterioration of the material is excessive. Such rejected material shall be replaced with acceptable material at no cost to the COMPANY.

7. The fill or aggregate shall be placed on the geotextile in compacted lifts not less than 6 inches thick. The minimum lift may be reduced to a 4 inch thickness at the discretion of the ENGINEER. Traffic shall not be permitted directly on the geotextile. Sudden stops or turns by equipment operating on aggregate placed over the geotextile shall be avoided. Any damage to the geotextile after installation shall be replaced by the CONTRACTOR at no cost to the COMPANY.

8. When used as a separator under track between ballast and subballast, a minimum 9" of ballast shall be placed on the fabric before tamping to avoid damaging the fabric.

Minimum Average Roll Value (Weakest Principal Direction)

Physical Property	Tests	A	B	C
Grab Tensile Strength *12" per min.*	ASTM D 4632 (lbs.) *(Jaw size 1" wide x 2" high)*	350	250	115
Elongation at Failure	ASTM D 4632 (%) *(Jaw size 1" wide x 2" high)*	60 min 115 max	60 min 115 max	60 min 115 max
Mullen Burst Strength	ASTM D 3786 (psi)	450	350	220
Trapezoidal Tear	ASTM D 4533 (lbs.) *(Jaw size 2" high x 3" wide)*	150	100	60
Puncture Strength *(5/16" flat tip end)*	ASTM D 4833 (lbs.) *(modified)*	160	130	60
Coefficient of Normal Permeability (Cm/Sec)	ASTM D 4491	0.1	0.1	0.1
Permittivity (Sec-1)	ASTM D 4491	0.30	0.25	0.20
Weight	Oz. per Square Yard	16	10	5

Table 1: Specified Physical Properties of Geotextiles

EF-5 Paving Fabric Applications

A. Description

This work shall consist of furnishing and placing an asphalt overlay textile (paving fabric) beneath a pavement overlay or between layers to provide a water resistant membrane and crack retarding layer.

B. Material

1. Paving fabric shall be a non-woven material consisting of polyester or polypropylene and be specifically designed for pavement overlay applications.

2. Paving fabric shall be resistant to chemical attack, rot and mildew and shall have no tears or defects which will adversely alter its physical properties.

3. Paving fabric shall meet the physical requirements of Table 2.

4. Heavy duty paving fabrics should be used in areas experiencing unusually high impact forces or heavy loads such as those produced by straddle cranes, straddle carriers or side loaders.

C. Installation

1. The paving fabric shall be kept dry and wrapped such that it is protected from the elements during shipping and storage. At no time shall the paving fabric be exposed to ultraviolet light for a period exceeding 14 days. Paving fabric rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover.

2. Asphalt surface shall be prepared as specified in Section AP - Asphalt of these Specifications.

3. Tack coat shall be applied as specified in Section AP - Asphalt of these Specifications.

4. The paving fabric shall be placed onto the tack coat using mechanical or manual laydown equipment capable of providing a smooth installation with a minimum amount of wrinkling or folding. The paving fabric shall be placed prior to the tack coat cooling and losing tackiness.

5. Paving fabric shall not be installed in areas where the overlay asphalt tapers to a thickness of less than 1.5 inches.

6. Excess paving fabric which extends beyond the edge of existing pavement or areas of tack coat application shall be trimmed or removed.

7. When asphalt emulsions are used, the emulsions shall be allowed to cure properly such that essentially no water moisture remains prior to placing the paving fabric.

8. Wrinkles or folds in excess of 1 inch shall be slit and laid flat.

9. All transverse joints and slit folds or wrinkles shall be shingle-lapped in the direction of the paving operation.

10. Brooming and/or pneumatic rolling will be required to maximize paving fabric contact with the pavement surface.

11. Additional hand-placed tack coat may be required at laps and repairs as determined by the ENGINEER to satisfy asphalt retention of the lapped paving fabric.

12. All areas with paving fabrics placed will be paved the same day. No traffic except necessary construction equipment will be allowed to drive on the paving fabric.

13. Turning of the paver and other vehicles shall be done gradually and kept to a minimum to avoid movement and damage to the paving fabric. Abrupt starts and stops shall also be avoided.

14. Damaged fabric shall be removed and replaced with same type of fabric at no expense to the COMPANY.

15. Overlaps shall be sufficient to ensure full closure of the joint but not to exceed 18 inches.

Property	Units	Standard Requirements	Heavy Duty Requirements	Test Method
Tensile	lb	80	120	ASTM D 4632
Elongation	%	50	50	ASTM D 4632
Asphalt Retention	gal/yd^2	0.2	0.3	Texas DOT 3099
Melting Point	F°	300	300	ASTM D 276
Surface Texture	--	Heat bonded on one side only	Heat bonded on one side only	Visual Inspection

** Certification of conformance from fabric manufacturer shall be required per this Section.*

*** All numerical values represent average roll min. values (weakest principle direction).*

Table 2: Paving Fabric Physical Requirements

EF-6 Erosion Control Applications

A. Description

This work shall consist of furnishing and installing slope matting or erosion control geotextiles beneath rip rap, gravel, gabions or other erosion protection material in accordance with these Specifications and the lines, grade, design and dimensions shown on the plans or as directed by the ENGINEER.

B. Material

1. Erosion control matting (blankets) shall conform to the following:

   a. Weave material should consist of photodegradable polypropylene.

b. Erosion control mats must have a minimum thickness of 3/8 inch and a maximum weight of 0.5 lb/SY. Mats must have a minimum longitudinal tensile strength of 20 lbs./inch and a minimum transverse tensile strength of 10 lbs./inch.

c. Matting shall meet the requirements described in Table 3 below:

Type	Duration (months)	Slope Range	Description	Fill Material	Width Max. (in.)	Top Side Mesh Size (in * in)	Max. Stich Spacing (in)
A	0-12	< 3:1	Single Net Erosion Control Mat	100% straw	48	5/16 * 5/16	1.5
B	0-12	3:1 to 2:1	Double Net Erosion Control Mat	100% straw	48	5/16 * 5/16	1.5
C	0-12	2:1 to 1:1		Coconut fiber/straw mix	48	5/8 * 5/8	1.5
D	0-24	> 1:1		100% cononut fiber	38	5/8 * 5/8	1.5
E	12-24	2:1 to 1:1		70% coconut fiber / 3% straw	38	5/8 * 5/8	2

Table 3: Physical Requirements for Erosion Control Matting

d. Unless otherwise noted on Plans, staples shall be 12-inch No. 11 steel wire bent into 1-inch wide U-shapes.

e. Unless otherwise noted on Plans, pins shall be 18-inch long 1/4-inch diameter steel with attached 1.5-inch washer.

2. The erosion control geotextiles shall be composed of synthetic fibers formed into a woven or nonwoven fabric.

a. Fibers used in manufacture of the geotextile shall be composed of polyesters or polypropylenes. They shall be formed into a network of filaments or yarns which retain dimensional stability relative to each other, including selvages under normal handling conditions. These materials shall conform to requirements of Tables 4 and 5.

b. The geotextile shall contain stabilizers and/or inhibitors to make the fibers resistant to deterioration resulting from exposure to sunlight or heat.

c. The geotextile shall be free of defects or flaws which significantly affect its physical and/or filtering properties.

Property	Units	Standard Requirements	Test Method
Tensile Strength	lb	90	ASTM D 4632
Elongation	%	15 - 50	ASTM D 4632
Permittivity	gal/min/ft	15	ASTM D 4491
Apparent Opening Size	Standard Sieve No.	20	ASTM D 4751
Ultraviolet Stability	%	80	ASTM D 4355

** All numeric values, except elongation, represent average roll minimum values (weakest principle direction). The values indicated for elongation are minimum and maximum values.*

Table 4: Physical Requirements for Woven Erosion Control Geotextile

Property	Units	Standard Requirements	Test Method
Tensile Strength	lb	90	ASTM D 4632
Elongation	%	50	ASTM D 4632
Permittivity	gal/min/ft	15	ASTM D 4491
Apparent Opening Size	Standard Sieve No.	70	ASTM D 4751
Ultraviolet Stability	%	80	ASTM D 4355

** All numeric values represent average roll minimum values (weakest principle direction).*

Table 5: Physical Requirements for Non-Woven Erosion Control Geotextile

Property	Units	Class S	Class A	Test Method
Tensile Strength	lb	300	200	ASTM D 4632
Elongation	%	15 - 50	15 - 50	ASTM D 4632
Seam Strength	lb	280	180	ASTM D 4632
Puncture Strength	lb	175	80	ASTM D 4833
Burst Strength	psi	800	320	ASTM D 3786
Trapezoid Tear	lb	120	50	ASTM D 4533
Permittivity	1 / sec	0.02	0.02	ASTM D 4491
Apparent Opening Size	Standard Sieve No.	50	70	ASTM D 4751
Ultraviolet Stability	%	70	70	ASTM D 4355

1) Class S erosion control geotextiles are recommended for severe installations such as those encountered when riprap pieces weighing more than 250 pounds are used.

2) Class A erosion control geotextiles are recommended for normal installation conditions such as those encountered when riprap pieces weighing less than 250 pounds are used.

3) All numerical values, except elongation, represent average roll minimum values (weakest principle direction). The values indicated for elongation are minimum and maximum values.

4) A nominal coefficient of permeability, k, for the geotextile may be determined by multiplying the permittivity value by the nominal thickness of the geotextile. The k value of the geotextile shall be greater than the k value of the soil. As general information the following soil permeability k values are assumed:

Sand:	10^-2 cm/sec
Silt:	10^-5 cm/sec
Clay:	10^-7 cm/sec

Table 6: Erosion Control Geotextile Physical Requirements

C. Installation

1. Erosion control geotextile shall be kept dry and wrapped such that it is protected from the elements during shipping and storage. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. At no time shall the stored erosion control geotextile be exposed to ultraviolet light for a period exceeding fourteen days.

2. Silt fence shall be installed and removed in accordance with Section ES - Erosion and Sediment Control of these Specifications and as shown on the plans.

3. Erosion control matting shall be placed on a smooth graded surface approved by the ENGINEER. The geotextile shall be placed in such a manner that it will not excessively stretch or tear upon placement of the overlying materials. Care should be taken to place the geotextile in intimate contact with the soil such that no void spaces exist between the underlying soil and the geotextile. Anchoring of the geotextile shall be accomplished through the use of key trenches or aprons at the crest and toe of slope.

4. Geotextile sheets shall be joined by either sewing or overlapping. All overlaps and seams shall be subject to the approval of the ENGINEER. Overlapped sheets shall have a minimum overlap of 18 inches except where placed underwater where the overlap shall be a minimum of 3 feet. Overlaps shall be constructed with the upstream sheet placed over the downstream sheet or the upslope sheet placed over the downslope sheet. All overlaps shall be pinned or stapled on 3 foot centers to hold the overlap in place during stone placement.

5. Care shall be taken during construction to avoid contamination of the geotextile. Contaminated geotextile shall be removed and replaced at no cost to the COMPANY.

6. Damaged geotextile shall be removed or repaired as directed by the ENGINEER at no cost to the COMPANY. A geotextile patch may be placed over damaged areas if approved by the ENGINEER. The patch shall extend 3 feet beyond the perimeter of the tear or damage.

EF-7 Drainage Applications

A. Description

This work shall consist of furnishing and placing a geotextile for the following drainage applications: edge of pavement drains, interceptor drains, wall drains, recharge basins and relief wells.

B. Material

1. Drainage geotextiles shall meet the physical requirements of Table 6 or as specified on the Plans. Fibers used in the manufacture of woven drainage geotextiles shall consist of polyesters or polypropylenes.

2. The geotextile and the threads used in sewing geotextiles shall be resistant to chemical attack, rot and mildew.

3. The geotextile shall have no tears or defects which adversely alter its physical properties.

Property	Units	Class A	Class B	Test Method
Tensile Strength	lb	180	80	ASTM D 4632
Elongation	%	n/a	n/a	ASTM D 4632
Seam Strength	lb	160	70	ASTM D 4632
Puncture Strength	lb	80	25	ASTM D 4833
Burst Strength	psi	290	130	ASTM D 3786
Trapezoid Tear	lb	50	25	ASTM D 4533
Permittivity	1 / sec	0.50	0.50	ASTM D 4491
Apparent Opening Size	Standard Sieve No.	70	70	ASTM D 4751
Ultraviolet Stability	%	70	70	ASTM D 4355

1) Class A Drainage applications are for geotextile installations where applied stresses are more severe than Class B applications; i.e., very coarse sharp angular aggregate is used, a minimum compaction energy greater than 95 percent of AASHTO T99, "Moisture-Density Relations of Soils Using a 5.5 pound [2.5 kg] Rammer and a 12 inch [305 mm] Drop", is specified, compaction of lifts less than 12 inches thick over the geotextile, or depth of trench is greater than 10 feet.

2) Class B Drainage applications are for geotextile installations where applied stresses are less severe than Class A application; i.e., smooth graded surfaces having no sharp angular projections, and no sharp angular aggregate, a minimum compaction energy less than or equal to 95 percent AASHTO T99, "Moisture-Density Relations of Soils Using a 5.5 pound [2.5 kg] Rammer and a 12 inch [305 mm] Drop", is specified and trenches are less than 10 feet in depth.

3) Numerical values represent average roll minimum values (weakest principle direction).

Table 7: Physical Requirements for Drainage Geotextiles

C. Installation

1. The drainage geotextile shall be kept dry and wrapped such that is protected from the elements during shipping and storage. At no time shall geotextile be exposed to ultraviolet light for a period exceeding 14 days. Geotextile rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover.

2. Prior to placement of the geotextile, the surface will be prepared to a smooth condition free of debris, depressions, or obstructions which may damage the textile.

3. The drainage geotextile shall be placed loosely (not taut) with no wrinkles or folds.

4. Care will be taken to place the geotextile in intimate contact with the soil so that no void spaces occur between the geotextile and the trench.

5. The geotextile shall be overlapped 12 inches or the full width of the trench, whichever is less, at the top of the trench. Additional overlap or anchoring may be

required as determined by the ENGINEER. The upstream geotextile shall be overlapped over the downstream.

6. Care should be taken during construction to avoid contamination of the geotextile with soil or other material. Contaminated geotextile shall be removed and replaced at no expense to the COMPANY.

EF-8 Geogrid Applications

A. Description

This work shall consist of furnishing and installing geogrids for base/subbase, subgrade, and/or pavement reinforcement.

B. Material

1. Geogrid shall consist of uni- or multi-axial polymeric grid formed by a regular network of integrally-connected tensile elements. Grid apertures shall be of sufficient size to allow interlocking with surrounding soil, rock, or pavement to function primarily as reinforcement.

2. Geogrid shall be formed from polypropylene, high-density polyethylene, glass fiber mesh, or other materials shown on the Plans.

3. Polymeric geogrid shall be at least 95% resistant to loss of load capacity or structural integrity when subjected to 500 hours of ultraviolet light and weathering in accordance with ASTM 4355-05.

4. Polymeric geogrid shall be at least 95% resistant to loss of load capacity or structural integrity when subjected to chemically aggressive environments in accordance with EPA 9090 immersion testing.

5. Pavement geogrids shall have a melting point above 425°F.

6. Pavement geogrids shall be self-adhesive with sufficient bond to allow for normal construction and paving operations.

7. Geogrid shall meet the requirements specified on the project Plans.

Property	Units	Minimum Value*	Test Method
Open Area	%	70.0	Direct Measurement
Rib Thickness	Inches (mm)	0.05 (1.27)	ASTM D1777
Junction Thickness	Inches (mm)	0.16 (4.0)	ASTM D1777
Aperture Stability Modulus (@ 20 cm-kg)	ft-lb/deg (cm-kg/deg)	0.470 (6.5)	USACE Test Method
Flexural Rigidity (Machine Direction)	ft-lb/deg (cm-kg/deg)	0.0542 (750,000)	ASTM D1388
Tensile Modulus @ 2% Strain**	lb/ft (kN/m)	18,500 x 30,000 (270 x 437)	ASTM D6637-01
Max. Elongation Break	%	5.0	ASTM D6637
Junction Strength	lb/ft (kN/m)	1,080 (15.7)	GRI GG2-87
Junction Efficiency	%	90.0	GRI GG2-87
Carbon Black	%	0.5	ASTM 4218

** Unless otherwise shown on plans, supplemental specifications, or bid sheet.*

*** Machine x Cross Machine Direction.*

Table 8: Physical Requirements for Geogrids

C. Installation

1. Prevent excessive mud, wet concrete, epoxy, or other deleterious materials from coming into contact with geogrids. Clean geogrids of deleterious material before installation.

2. Geogrids must be stored at the temperatures and conditions recommended by the Manufacturer. Protect geogrids from ultraviolet degredation as required by the Manufacturer.

3. Transverse joints shall be lapped by no less than 3 feet or as shown on the Plans.

4. Longitudinal joints shall be lapped by no less than 2 feet or as shown on the Plans.

5. Geogrid shall be laid by hand or mechanical means with sufficient tension to eliminate rippling. All ripples shall be eliminated by pulling the grid tight. Ripples may be removed by cutting and laying the geogrid flat only in extreme curves where approved by the ENGINEER in accordance with Manufacturer's instructions.

6. Pavement geogrid installation must comply with the following:

   a. Pavement geogrids shall be installed per Manufacturer's instructions. Geogrids shall be cut or modified only by the methods approved by the Manufacturer.

   b. CONTRACTOR shall perform all remedial pavement work indicated on Plans or Bid Documents prior to laying geogrid.

c. A tack coat shall be applied as part of geogrid installation unless otherwise specified on Plans or by the ENGINEER. CONTRACTOR shall furnish and install tack coat as recommended by geogrid Manufacturer.

d. Mesh shall be rolled with a rubber-coated drum roller, pneumatic tire roller, or other method approved by the Manufacturer and ENGINEER. The CONTRACTOR shall make the number of passes required to activate the adhesives, and shall clean tires or rollers regularly with asphalt cleaning agents.

e. CONTRACTOR shall protect placed geogrid from excessive traffic between rolling and asphalt overlay.

7. Subgrade or base/subbase geogrid installation must comply with the following:

a. Geogrid shall be installed per Manufacturer's instructions. Geogrids shall be cut or modified only by the methods approved by the Manufacturer.

b. Surface shall be cleaned of debris and constructed to the proper grade as shown in the Plans prior to installation.

c. CONTRACTOR shall protect geogrid from degradation during construction.

d. Geogrid may be temporarily secured using ties, staples, pins, sand bags, or backfill.

e. Unless otherwise shown in Plans, CONTRACTOR shall backfill geogrid with an initial 6-inch lift using the material specified in the Plans. Turning of tracked vehicles should be kept to a minimum in order to prevent damage to the geogrid.

EF-9 Measurement and Payment

A. Measurement

1. Separation application geotextile shall be measured by the number of square yards installed. Seams and overlaps shall not be included in the measurement.

2. Paving fabric shall be measured by the number of square yards installed. Seams and overlaps shall not be included in the measurement.

3. Erosion control geotextile shall be measured by the number of square yards installed. Measurement shall not include seams and overlaps but shall include material used in the crest and toes of slopes.

4. Drainage geotextile shall be measured by the number of square yards installed. Measurement shall not include seams or overlays.

5. Geogrid shall be measured by the number of square yards of material installed. Measurement shall not include seams or overlays.

B. Payment

1. Payment for separation application geotextiles will be made at the Contract unit bid price per square yard of geotextiles installed, which price shall include all necessary material, labor and equipment.

2. Payment for paving fabric will be made at the Contract unit bid price per square yard of paving fabric installed, which price shall include all necessary material, labor and equipment.

3. Payment for erosion control geotextile will be made at the Contract unit bid price per square yard of erosion control geotextile or grid installed, which price shall include all necessary material, labor and equipment.

4. Payment for drainage geotextile will be made at the Contract unit bid price per square yard of drainage geotextile installed, which price shall include all necessary material, labor and equipment.

5. Payment for subgrade and base/subbase geogrid shall be made at the Contract unit price per square yard installed. Price shall include all necessary material, labor, and equipment.

6. Payment for pavement geogrid shall be made at the Contract unit price per square yard installed. Price shall include all necessary material, labor, and equipment. If specified, payment shall also include a tack coat in accordance with Manufacturer's recommendations.

END OF SECTION

Section ES – Erosion and Sediment Control

ES-1 Description

The Work shall consist of the installation, maintenance and disposition, where required, of erosion and sediment control devices required to protect the general area including the adjoining property, streams, rivers and lakes from erosion and sediment damage resulting from construction (land disturbing) activities.

Erosion and sediment control devices shall be constructed, maintained, and removed as shown on the plans or specified herein at locations shown on the plans or specified by the ENGINEER. If in conflict, any environmental or construction permit requirements or supplemental specifications supercede these requirements.

ES-2 General

A. All work shall be performed in accordance with applicable local, State, and Federal regulations and permits. Project erosion and sediment control plans, stormwater pollution prevention plans, and other documents required by permit take precedence. If no soil erosion control plan is provided, all work must conform to the current edition of "Norfolk Southern's General Plan for Erosion and Sediment Control."

B. Erosion and sediment control devices shall be in full compliance with all local, State and Federal laws governing land disturbing activities. The CONTRACTOR shall maintain a written record which documents the date(s) of all ES installations and removals, the date(s) of all ES inspections, and the date(s) of all ES maintenance that is undertaken. Record shall be maintained for duration of project. Additional reporting may be required subject to permitting requirements.

C. Stabilization of denuded areas and soil stockpiles shall meet the following requirements:

1. Permanent or temporary soil stabilization shall be applied to denuded areas within 7 days after final grade is reached on any portion of the site. Soil stabilization shall also be applied within 7 days to denuded areas which may not be at final grade, but which shall remain undisturbed for a period exceeding 30 days. Permanent stabilization shall be applied to areas will be dormant for more than one year.

2. In areas to be paved, stabilization shall be accomplished through placement of subbase materials (i.e., compacted crushed stone).

3. Soil stockpiles shall be stabilized by compaction and protected if necessary with a silt fence or seeding.

4. Locations requiring seeding shall be designated by the ENGINEER or on the Plans.

5. Seeding shall be in accordance with Section SM - Seeding and Mulching of these Specifications.

D. Brush barriers shall meet the following requirements:

1. Brush barriers shall be placed on natural ground at the bottom of a fill slope where erosion is likely.

2. Barriers utilizing brush, foliage, plants, logs, or other materials that are available from the clearing operation shall be completed for a minimum distance of 200 feet ahead of grading operations.

3. Size of brush barriers will vary depending on the location and the requirement of each. The height shall vary from 3 - 5 feet when compressed, the thickness from 5 - 13 feet and the length shall be as required.

4. Brush barriers may be supplemented where required by use of other types of siltation control devices where brush is not readily available.

E. Straw bale barriers shall meet the following requirements:

1. Bale size shall be a minimum of 5 cubic feet.

2. Bales shall be placed in a single row with ends of adjacent bales tightly abutting one another.

3. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings.

4. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of a proposed barrier to a minimum depth of 4 inches. After the bales are staked and chinked (gaps filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier.

5. Each bale shall be securely anchored by at least two wood stakes, minimum dimensions of 2 inches x 2 inches x 3 feet, or steel posts (standard "U" or "T" section), minimum weight of 1.33 pounds per linear foot, driven through the bale a minimum of 18 inches into the ground. The first stake or steel post in each bale shall be driven toward the previously laid bale to force the bales together.

F. Temporary filter barriers (silt fences) consisting of a water permeable filter type of fence to remove suspended particles in runoff water shall meet the following requirements unless specifically otherwise shown on the plans:

1. Materials shall meet the following requirements:

a. Wooden stakes shall have a diameter 2 inches when oak is used and 4 inches when pine is used. Wooden stake shall have a minimum length of 6 feet.

b. Steel posts (standard "U" or "T" section) shall have a minimum weight of 1.33 pounds per linear foot and shall have a minimum length of 6 feet.

c. The erosion control fabric shall be composed of synthetic fibers formed into a woven or nonwoven fabric according to the requirements shown in Section EF – Engineering Fabric and Geogrid (Erosion Control Applications). Fabric must also comply with the following:

i. Fabric shall have a minimum width of 36 inches or as shown on Plans.

ii. Fabric shall be resistant to ultraviolet degradation.

d. Staples shall be used to attach the fabric to the wooden stakes. Staples shall be No. 9 gage galvanized steel strand wire and shall not be less than 1-1/2 inches long.

e. If required, wire reinforcement shall consist of 14-guage galvanized wire mesh constructed in a 2"x4" grid or as shown on Plans.

2. Installation shall be as follows:

a. The height of the fabric barrier shall be a minimum of 16 inches above the original ground surface and shall not exceed 33 inches above the ground elevation.

b. A trench shall be excavated approximately 4 inches wide and 4 inches deep on the upslope side of the proposed filter fabric barrier.

c. Wooden stakes or metal posts shall be placed a maximum of 6 feet apart with a maximum projection of 3 feet above the ground. The filter fabric shall be fastened securely to the upslope side of the wooden stakes or metal posts using wire staples, tie wires, or pockets and a minimum of 3 inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees.

d. If a fabric barrier is to be constructed across a ditch line or swale, the device must be of sufficient length to eliminate endflow, and the plan configuration shall resemble an arc or horseshoe with the ends oriented upslope. Wooden stakes or metal posts shall be placed a maximum of 3 feet apart. All other installation requirements in paragraph c apply.

e. The trench shall be backfilled and the soil compacted over the filter fabric.

G. Filter socks

1. Filter socks shall consist of a three-dimensional tubular socks filled with composted material per manufacturer's instructions.

2. Install filter socks perpendicular to slope directions as indicated on the Plans.

3. Anchor socks a maximum 10 feet on center with 2”x2”x36” wooden stakes. Stakes shall extend at least 12 inches into the ground, fully through the diameter of the sock, and no more than 4 inches above the sock.

H. Burlap drop inlet sediment filters shall be used to protect storm sewer inlets made operable during construction so that sediment-laden water shall not enter the conveyance system without first being filtered or otherwise treated to remove sediment and shall meet the following requirements:

1. Materials shall meet the following requirements:

a. Burlap shall weigh 10 ounces per square yard and be cut from a continuous roll to avoid joints.

b. Stakes shall be 1 inch x 2 inches wood with a minimum length of 3 feet.

c. Staples shall be No. 9 gage galvanized steel strand wire and shall be 1-1/2 inches long.

2. Installation shall be as follows:

a. Stakes shall be spaced around the perimeter of the inlet a maximum of 3 feet on centers and driven into the ground a minimum of 8 inches.

b. A 4 inch x 4 inch trench shall be excavated around the outside perimeter of the stakes.

c. The burlap shall be stapled to the wooden stakes and 8 inches of the fabric shall extend into the trench. The height of the barrier shall be a minimum of 15 inches and a maximum of 18 inches.

d. The trench shall be backfilled and the soil compacted over the burlap.

I. Gravel construction entrances shall meet the following, unless otherwise specified:

1. Coarse aggregate shall conform to Type C1 erosion stone as found in Appendix A, Table 3 of Section GA - Graded Aggregate of these Specifications.

2. The entrance shall be constructed as shown on the plans at locations where construction vehicles enter or access paved public roads or other paved areas.

J. Sediment basins shall be constructed, if necessary, as shown on the plans or as directed by the ENGINEER.

K. Temporary slope drains, temporary diversion dikes, temporary fill diversions and temporary right of way diversions shall be constructed as shown on the plans or at locations specified by the ENGINEER.

L. Check dams shall be constructed as shown on the plans in swales, ditches and natural drainways (other than live streams) to reduce the velocity of concentrated stormwater flows. Coarse aggregate shall conform to Type C1 erosion stone as found in Appendix A, Table 3 of Section GA - Graded Aggregate of these Specifications.

M. Temporary stream crossings shall be constructed, if necessary, as shown on the plans or as directed by the ENGINEER.

N. Temporary pipes for stream crossings, slope drains, or other structures shall be installed in accordance with section DR – Drainage.

ES-3 Maintenance

A. Straw bale barriers, silt fences, and filter socks shall be inspected at least weekly and after each rainfall. Required repairs shall be made immediately. Sediment deposits shall be removed prior to exceeding one-half the height of the barrier.

B. Temporary diversion dikes and temporary right of way diversions shall be inspected weekly and after each significant rainfall. Temporary fill diversions shall be inspected daily. Required repairs shall be made to each structure immediately following a detection of a failure.

C. Temporary sediment basins, or traps, shall be inspected weekly. Sediment shall be removed and the sediment basin restored to its original capacity prior to accumulation of one-half its volume. The sediment basin embankment and spillway shall be inspected to assure that they remain structurally sound.

D. All other erosion and sediment control practices shall be inspected weekly and necessary repairs made immediately.

E. If the graded aggregate construction entrance becomes ineffective so that the majority of mud is not removed from the wheels of construction vehicles prior to the vehicles entering a paved area, the CONTRACTOR shall either reconstruct the entrance with fresh graded aggregate or wash the vehicle's tires before it enters a paved area. Where sediment is deposited on a public road surface, it shall be removed by shoveling or sweeping at the end of each work day. Sediment and sediment-laden water shall be deposited into a sediment control disposal area designated by the ENGINEER.

ES-4 Disposition of Temporary Measures

A. All temporary erosion and sediment control measures shall be disposed of within 30 days after final site stabilization is achieved or after the temporary measures are no longer needed.

B. Trapped sediment or other disturbed soil areas resulting from the disposition of temporary measures shall be permanently stabilized to prevent further erosion and sedimentation.

C. Straw bales, when no longer needed, may be broken apart and spread around the construction site.

ES-5 Measurement and Payment

A. Measurement

1. Permanent and temporary soil stabilization by temporary or permanent seeding and mulching shall be measured in accordance with Section SM - Seeding and Mulching of this Specification.

2. Straw bale barriers shall be measured per bale of straw placed.

3. Temporary silt fencing shall be measured by the number of linear feet of silt fence installed.

4. Filter socks shall be measured by the number of linear feet of filter sock installed per the sock size.

5. Burlap drop inlet soil filters shall be measured per each of burlap filter installed.

6. Coarse graded aggregate used for erosion and sediment control measures shall be measured in accordance with Section GA - Graded Aggregate of these Specifications.

7. There shall be no separate measurements of brush barriers, temporary sediments basins and temporary erosion and sediment control measures constructed of soil for measures incidental to grading. This includes temporary right of way diversions, temporary fill diversions or temporary diversion dikes.

8. Slope drains shall be measured per linear foot of drain installed, including fabric, stone, and anchoring.

9. Temporary pipe crossings shall be measure per linear foot of pipe installed by size and type of pipe, including fabric, stone, and anchoring.

10. Other temporary pipes shall be measure per linear foot of pipe installed by size and type of pipe, including fabric, stone, and anchoring.

B. Payment

1. Payment for permanent and temporary soil stabilization by temporary or permanent seeding and mulching will be made in accordance with Section SM - Seeding and Mulching of these Specifications.

2. Payment for straw bale barriers will be made at the Contract unit price per each bale installed, which price shall include all necessary material, labor and equipment.

3. Payment for temporary silt fence will be made at the Contract unit price per linear foot of temporary silt fence installed, which price shall include all necessary material, labor and equipment.

4. Payment for filter socks will be made at the Contract unit price per linear foot of filter sock installed, which price shall include all necessary material, labor and equipment.

5. Payment for burlap drop inlet soil filters will be made at the Contract unit price per each burlap drop inlet soil filter installed, which price shall include all necessary material, labor and equipment.

6. Payment for coarse graded aggregate used for erosion and sediment control measures will be made in accordance with Section GA - Graded Aggregate of these Specifications.

7. Payment for the construction of brush barriers will be in accordance with Section CG - Clearing and Grubbing of these Specifications.

8. Payment for slope drains will be made at the Contract unit price per linear foot of drain installed, which price shall include all necessary material, labor, equipment, fabric, and stone.

9. Payment for temporary pipes shall be paid per linear foot installed, including all necessary labor, materials, and equipment as shown on the Plans.

10. Payment for temporary sediment pond riser pipes and outlet structures shall be paid per each structure installed, including all necessary material, labor, equipment, excavation, backfill, filter fabric, outlet and inlet piping, and other features as shown on Plans.

11. For all measures, payment will include the cost to inspect, repair (includes labor, materials and equipment costs) and to remove erosion and sediment control devices and to remove accumulated silt and debris from the COMPANY's right of way.

12. There will be no separate payment made for the construction, maintenance and removal of temporary sediment basins, temporary diversion dikes, temporary fill diversions, or temporary right of way diversions.

END OF SECTION

Section GR – Grading

GR-1 Description

The Work shall include the construction of all cuts and fills required to form the roadbed, dikes, ditches, or waterways. Such Work shall include excavation, placement and compaction of material as required and the disposal of all excess material.

GR-2 General Conditions

A. Construction shall conform to the survey stakes as set by the ENGINEER and to the section, slope and dimensions shown on the plans.

B. The subgrade finish tolerance shall be within 0.1 foot of the elevation shown on the plans.

C. All surfaces shall be shaped at all times to prevent the ponding of water.

D. Excavation shall consist of one or more of the following classifications:

1. Unclassified Excavation

2. Borrow

3. Undercutting or Mucking

4. Stripping (Removal of topsoil and organics) - Included in Section CG - Clearing and Grubbing of these Specifications.

E. All excavation other than borrow or mucking shall be considered as unclassified regardless of the nature of the material.

F. Earthwork operations shall be performed in a manner to minimize erosion and sedimentation of adjacent streams, pond, or other waterways. Erosion and sediment control practices shall conform to Section ES-Erosion and Sediment Control of these Specifications.

G. CONTRACTOR shall comply with all federal, state and local laws.

H. In the course of grading near tracks, it may be necessary to work in stages in order not to interfere with train operations. No claim shall be made by the CONTRACTOR for any delay due to staging of his work.

I. Grading operations that may foul adjacent track and are performed within 15 feet of the track must be performed with the authorization of and in the presence of a COMPANY flagman. The CONTRACTOR's equipment working within 25 feet of a track must halt operations when a train is passing. No claim shall be made by the CONTRACTOR for delay due to restrictions enforced by the COMPANY's flagman. CONTRACTOR shall

erect temporary construction fence as directed by the ENGINEER to limit access of the CONTRACTOR's equipment or personnel to area that may foul tracks.

J. CONTRACTOR shall be required to exercise every precaution to eliminate dust caused by or resulting from his grading operations and subsequent operations over the graded area by the application of water or other appropriate methods. In case of repeated failure to control the dust, the COMPANY reserves the right to employ another CONTRACTOR to provide the necessary corrective measures. Such incurred direct costs shall be charged to the CONTRACTOR with appropriate deductions made from the CONTRACTOR's monthly estimate.

GR-3 Placement of Fill Material

A. Construction of fills shall consist of the excavation, hauling, placement and compaction of suitable fill materials as well as the backfilling of stump or demolition holes and correcting other surface irregularities prior to placement of the fill material.

B. All earth fills shall be made in uniform layers of not more than 6 inches thick after compaction. Rock may be placed in compacted layers of not more than 24 inches thick. Each fully compacted layer shall extend the full width of the cross section.

C. Each layer shall be free from mud, snow, ice, or excessive (standing) water when a subsequent layer is placed.

D. Sandy or rocky material shall be spread in full width layers to form drainage planes from the center through the edge of the embankment. Pockets of open materials surrounded by more impervious material shall be avoided.

E. No side dumping of fill material shall be allowed except slight flushing of the completed fill to replace material lost by erosion.

F. Fill shall be formed with suitable materials from on-site cuts and/or necessary suitable material from borrow pits. Organic material such as brush, stumps, roots and trees or other perishable items shall not be placed in embankments.

G. If rock is used as embankment material, voids shall be filled with a fine material. Rocks larger than 4 inches in any dimension shall not be placed within 12 inches of the finished subgrade elevation. Coal or organic shale shall not be included in the embankment

H. In construction embankments over or against junction boxes, culverts, retaining walls, or other structures, only the best available materials shall be used. No rock more than 4 inches in diameter shall be placed within 12 inches of any structure. Embankment to be placed on both sides of a wall, junction box, arch, culvert, or other structure shall be brought up equally on both sides. Waterproofing on structures must not be damaged during the fill operation.

I. When a fill is to be placed against an existing embankment or hillside, the existing surface shall be continuously stepped or benched as the fill is placed in lifts. Each

successive bench cut shall begin at the intersection of the original ground line and the vertical side of the previous cut and extend into the existing slope a minimum of 3 feet or a distance to permit the operation of equipment. All existing embankment material, except topsoil and organic material, removed shall be used as much as practicable in the new embankment.

J. The height and width of fills shall be increased as deemed necessary to provide for shrinkage and erosion. Slopes shall be maintained to the proper height, dimension and shape. Any erosion or gullying of slopes shall be promptly restored and repaired. Any drainage conditions that are causing slope erosion shall be promptly corrected or controlled.

K. Where fills or subgrades are to be constructed and ponded or standing water is encountered, CONTRACTOR shall provide temporary and/or permanent ditches and/or culvert well in advance of the placement of fill materials, subgrade preparation, dewatering, or removal of muck.

L. The CONTRACTOR may be restricted from using partial or completed roadbed as construction haul roads. Any embankment or roadbed that is damaged by hauling activities shall be repaired by the CONTRACTOR at no cost to the COMPANY.

GR-4 Compaction of Subgrades and Fills

A. In a fill section, after stripping topsoil and organic material, the entire area which the embankment is to be placed shall be plowed and scarified for a minimum depth of 6 inches. This surface and all future fill layers shall be compacted to 95 percent of maximum density per Standard Proctor in accordance with ASTM D698-T and AASHTO T 99, or 90 percent of maximum density per Modified Proctor in accordance with ASTM D-1557AASHTO T180, except that a minimum of the top 2 feet of fill shall be compacted to 100 percent Standard Proctor. The top 12 inches of the subgrade in cuts shall be plowed, scarified and compacted to 100 percent Standard Proctor. The ENGINEER shall determine the AASHTO test method to be used after review of the soil analysis.

B. The CONTRACTOR shall notify the ENGINEER of when fill layers are ready for compaction testing. Successive layers shall not be placed prior to compaction testing. The CONTRACTOR shall not make any claims for delay to work due to compaction testing.

C. Field testing for density control for fill and subgrade materials shall be made in accordance with the requirements of AASHTO T 191 and T 205 or by use of a portable nuclear density testing device with field test locations selected by the ENGINEER. All soil tests shall be performed at the expense of the COMPANY by COMPANY personnel or COMPANY's consultant. Testing shall not relieve the CONTRACTOR of the responsibility for ensuring that the work is performed in accordance with these Specifications.

D. CONTRACTOR may increase the depths of successive fill layers beyond the depths specified in subsection GR-3 if tests, performed at his expense, determine that the specified densities can be obtained for the increased layer's depths.

E. Moisture content of soil shall be controlled as necessary to obtain the specified densities based upon the optimum moisture content for each material. Water shall be added to the soil when, in the opinion of the ENGINEER, additional moisture may be necessary to obtain the specified density. Soil that is too wet shall be allowed to dry or be worked by plowing, disking, harrowing, or other means to dry the material to a workable moisture content.

F. In the event a specified density is not obtained, the ENGINEER may order additional rolling, watering, or drying of the soil as necessary to obtain the specified density. Fill layers not meeting a specified density after additional working shall be removed and new material shall be placed and compacted to the specified density at no cost to the COMPANY.

G. The lower part of fills constructed across inundated areas shall be built by dumping successive loads of rock in layers no thicker than necessary to support the hauling equipment. Succeeding layers shall be constructed as specified herein.

H. Rutted areas shall be immediately excavated of unstable material and replaced with rock or suitable earth fill and compacted to prevent additional rutting.

GR-5 Rock Excavation

A. Side slopes in rock cuts shall be formed by the general method of shaping them concurrently with or after the removal of material from the cut or by the method of advance presplitting of the rock along the required plane by blasting. If the method used by the CONTRACTOR is not producing acceptable results, the ENGINEER may require a change in method.

B. Prior to the commencement of blasting operations, the CONTRACTOR shall submit to the ENGINEER for approval a blasting plan, a loading plan and the type of initiation system (electrical caps are not allowed), etc. An evaluation and seismic report for each shot shall be furnished to the ENGINEER. In the event the maximum peak vector is exceeded, or unexpected results occur, the CONTRACTOR shall furnish an analysis of the affects on the surrounding conditions, i.e., structures, geology, etc., and the proposed changes to the blasting plan to correct the action, to the ENGINEER for review and approval before continuing blasting operations.

C. Presplitting shall be performed in such manner as to produce a uniform plane of rupture in the rock and such that the resulting backslope face shall be unaffected by subsequent blasting and excavation operations within the section. The plane shall be formed for the entire depth of the cut or to a predetermined bench level. Presplitting shall be accomplished by drilling holes of the approximate diameter to the desired depth with a maximum hole spacing of 24 inches. An increase in hole spacing may be approved by

the ENGINEER as long as slopes with a surface reasonable free of loose rocks are produced. All holes shall be detonated simultaneously by the use of a trunk line. Presplitting shall be performed well in advance of other drilling and blasting.

D. Primary blasting shall be performed in such a way that rock outside the authorized excavation lines shall not be unduly loosened. If rock below the line of the side slope is loosened by presplitting or primary blasting to such an extent to render it liable to slip or slide, the loosened rock shall be removed by the CONTRACTOR as specified in subsection GR-6. Rock cuts shall be removed to a depth of 12 inches below the proposed subgrade elevation and refilled to the subgrade elevation with approved material.

E. Blasting shall not be done without proper precaution to protect adjacent work, property and persons and then only with the ENGINEER's approval, but such approval shall not relieve the CONTRACTOR from liability. Blasting shall be in accordance with all federal, state and local laws, codes and ordinances. Blasting personnel shall be licensed when required.

F. The CONTRACTOR shall control blast mechanical effects such as heaving by displacement with the use of steel cables, mats, or other device. No blasting shall be performed without the presence of the ENGINEER or his authorized representative. In the event the ENGINEER determines blasting to be too hazardous, it shall be discontinued.

GR-6 Excess Excavation and Slides

A. Excavation in excess of that authorized, as well as slides extending beyond the slope lines, shall not be paid for unless due to causes beyond the control of the CONTRACTOR. In all cases, surplus material from slides shall be removed and the slope reformed.

GR-7 Sink Holes

A. In the event that sink holes are encountered within the construction limits, and are not necessary for future drainage, they shall be undercut and/or mucked as necessary to remove all soft materials. Areas shall then be backfilled as previously specified with stone or other approved material. If so directed by the ENGINEER, the CONTRACTOR shall blast the areas to insure proper settlement before or during filling.

B. In the event the sink hole is necessary for future drainage, it shall be kept open by means of rock drains, culverts, or by other methods as may be shown on the plans.

GR-8 Berms and Benches

A. Berms shall be constructed as shown on the plans or as directed by the ENGINEER. Material excavated for the berm ditch shall be placed and compacted in a windrow between the ditch and the top of the cut slope.

B. Benches shall be constructed as shown on the plans or as directed by the ENGINEER. In no case shall a bench width of less than 10 feet be allowed.

GR-9 Borrow

A. Borrow shall be defined as that material from outside the COMPANY's property furnished by the CONTRACTOR that is required to complete the embankment. Materials that may be excavated from the further widening of a proposed roadbed section in cuts, construction of side slopes in cut sections with a slope less than originally proposed, or that are otherwise available on COMPANY property, shall be considered as unclassified excavation and not as borrow. All borrow other than designated on the plans shall be subject to the prior approval of the ENGINEER.

B. CONTRACTOR shall provide written evidence to the ENGINEER where by approval has been granted by the property owner of the proposed borrow source.

C. Borrowing shall disfigure the land as little as possible and shall be formed and ditched to allow drainage unless suitable for development as ponds or lakes.

D. Construction of borrow pits that are not self-draining shall meet the requirements of any applicable state or local codes or ordinances and shall be subject to the approval of the property owner.

E. Clearing and grubbing required for the borrow pit, whether on or off the COMPANY's property, shall meet the requirements of Section CG - Clearing and Grubbing of these Specifications.

F. Construction of borrow pits within the COMPANY's property shall not use a steeper side slope ratio than shown on the plans for the adjacent roadbed or as directed by the ENGINEER.

G. Borrow pits on COMPANY's property shall be seeded and mulched in accordance with Section SM - Seeding and Mulching of these Specifications. Seeding and mulching of borrow pits off the COMPANY's property shall meet the requirements of the property owner.

H. All excavation work in borrow pits must comply with Federal NPDES requirements. The CONTRACTOR is responsible for obtaining any required permits that the COMPANY has not already obtained. All permit submittals must be approved by the ENGINEER prior to submission to permitting authorities.

GR-10 Undercutting and Mucking

A. Unstable materials found in marshes, muddy areas, drainage basins, swamps, or other unstable areas within the construction limits shall be undercut to a depth as directed by the ENGINEER and backfilled and compacted with approved material to the original elevation. Backfilling and compaction shall be in accordance with subsections GR-3 and GR-4 , respectively.

B. Removal of unsuitable material that requires the mobilization of special equipment such as a dragline shall be classified as mucking. Mucking shall be subject to the prior approval of the ENGINEER. Mucking shall be a separate pay item from any undercutting, or other excavations.

C. Areas that are undercut or mucked shall be measured by cross sections to determine the volume of undercutting.

D. Undercut or mucked material shall be disposed of in accordance with subsection GR-11.

GR-11 Disposal of Excavated Material

A. Excavated materials which are suitable for use in fills shall be used the extent needed. All excess suitable fill materials may be disposed of along the existing railroad embankment, in disposal areas on the COMPANY's property designated on the plans, or on property provided by the CONTRACTOR.

B. If disposed of on the COMPANY's property, all requirements of these Specifications will be adhered to. This includes, but is not limeted to, clearing and grubbing, placement of fill material, benching if adjacent to an existing fill, compaction of the material, seeding and mulching.

C. Seeding and mulching off the COMPANY's property shall be dependent upon the requirements of the property owner.

D. Disposal banks or piles shall not interfere with existing or proposed drainage.

E. Excess suitable fill material used in widening existing railroad embankments shall be shaped to drain away from the roadbed and shall not be at an higher elevation than that of the adjacent subgrade. If not shown on the plans, the slope shall be as specified by the ENGINEER.

F. Any snow, ice, stumps, roots, logs, unsuitable top soil, undercut or mucked material, and any other unsuitable materials shall not be used in fill construction and shall be disposed of off the COMPANY's property.

G. Disposal of any material dredged or excavated from a waterway should be performed in accordance with applicable State requirements. The CONTRACTOR shall not dispose material off of COMPANY property without approval of the ENGINEER.

GR-12 Measurement and Payment

A. Measurement

1. The quantity of unclassified excavation work shall be measured in cubic yards of unclassified excavation, which shall be the material actually moved and disposed of in accordance with these Specifications, as computed by the ENGINEER from original and final cross sections.

2. The quantity of borrow, as previously defined, shall be measured in cubic yards. It is determined by the ENGINEER from original and final project cross sections. The quantity is the difference of total cubic yards of embankment in place and total cubic yards of unclassified excavation obtained on-site.

3. The quantity of undercut material shall be measured in cubic yards of material undercut and disposed of in accordance with these Specifications, as computed by the ENGINEER from original and final cross sections.

4. The quantity of mucking (undercutting requiring the use of special equipment not adherent to the roadbed grading work) shall be measured by the cubic yard of material removed and disposed of as computed by the ENGINEER from original and final cross sections.

5. The quantity of areas seeded within the construction limits shall be measured in accordance with Section SM- Seeding and Mulching of these Specifications.

6. The quantity of any additional rock needed for backfill of undercut areas, in addition to that obtained from on-site excavation, shall be measured in accordance with Section GA - Graded Aggregate of these Specifications.

7. The quantity of areas cleared and grubbed within the construction limits shall be measured in accordance with Section CG - Clearing and Grubbing.

B. Payment

1. Payment for unclassified excavation will be made at the Contract unit price per cubic yard of unclassified excavation, which price shall include all necessary labor, tools and equipment.

2. Payment for material undercut will be paid at the Contact unit price per cubic yard of unclassified excavation.

3. Payment for borrow will be made at the Contract unit price per cubic yard of borrow, which price shall include all necessary labor, tools and equipment.

4. Payment for mucking will be made at the Contract unit price per cubic yard of mucking, which price shall include all necessary labor, tools and equipment.

5. Payment for clearing and grubbing of areas within the construction limits will be made in accordance with Section SM – Seeding and Mulching of these Specifications.

6. Soil stripping (removal of topsoil and organics) shall be paid as part of the following unit prices:

   a. For fill areas, stripping shall be included in the unit price for Clearing and Grubbing.

b. For cut areas, stripping shall be included in the unit price for unclassified excavation or other grading quantity.

7. Payment for seeding and mulching of borrow or disposal areas within the construction limits will be made in accordance with Section CG - Clearing and Grubbing of these Specifications.

8. Payment for any additional rock used as undercut backfill, in addition to that obtained from on-site excavation, will be made in accordance with Section GA - Graded Aggregate of these Specifications.

9. There will be no separate payment for clearing and grubbing or seeding and mulching of borrow pits outside of the COMPANY's property.

10. There will be no separate payment for benching of existing slopes to accommodate an embankment.

11. There will be no separate payment for rock encountered in soil cuts that are removed by ripping.

END OF SECTION

Section LA – Landscaping

LA-1 Description

Work shall include furnishing and installing trees, shrubs, sod, and other plantings as shown on the project Plans. Completion of the work shall include full and exact compliance with these specifications, and maintenance and watering until the latter of the final acceptance of the landscaping or final completion of the overall project.

LA-2 Material

A. Nomenclature shall conform to the names given in the current edition of Standardized Plant Names published by the American Joint Committee on Horticultural Nomenclature. Names of varieties not included therein shall conform generally with names accepted in the nursery trade.

B. Plantings:

1. Plants shall be measured when branches are in their normal position. Height and spread dimensions specified refer to main body of plant and not extreme branches tip-to-tip. The measurements specified are the minimum size acceptable and are the measurements after pruning, where pruning is required.

2. Trees, shrubs, and other plantings shall be grown in a recognized nursery in accordance with good horticultural practice and local and State regulations.

3. Provide healthy vigorous stock grown under climatic conditions similar to conditions in the project area.

4. Plantings shall be free of disease, insects, eggs, larvae, and defects such as knots, sun-scald, injuries, abrasions, or disfigurements.

5. Container-grown plants shall not be excessively root-bound.

6. No plant shall be accepted when the ball of earth surrounding its roots has been cracked or broken. The diameter of the ball must be sufficient to encompass the woody and non-woody roots necessary for the maximum development of the plant. Plants shall be hardened off at the nursery prior to installation. Non-woody roots shall be visible on 40% of the rootball growing through the burlap. Anti-transpirant spray shall be applied immediately following installation.

C. Sod:

1. Sod shall be of firm, tough texture having a compact growth of grass with good root development.

2. The soil embedded in the sod shall be good clean earth that is free from stones and debris.

3. Sod shall be free from fungus, vermin, and other diseases, and shall not contain weeds or any other objectionable vegetation.

D. Fertilizers:

1. Fertilizer shall conform to ANSI A-300 Part 2.

2. Fertilizers for trees and shrubs shall have a ratio of 3:1:1 or 3:1:2 and fertilizers for palms shall have a ratio of 3:1:3. Fertilizers shall have a salt index of less than 50. Fertilizers shall be applied at a rate of 2-4 pounds nitrogen per 1,000 square feet, not to exceed 6 pounds per 1,000 square feet annually.

3. Sod areas shall be treated with a 6-6-6 fertilizer, 100% organic, with minor elements, applied at a rate of twenty (20) pounds nitrogen per 1,000 square feet. Seeded areas shall conform to section SM – Seeding and Mulching.

4. A minimum of 50% of the total nitrogen shall be water-insoluble.

E. Native plant material collected from field locations shall only be allowed as noted on Plans. Native plant materials shall be excavated and transported with care in accordance with local practice.

LA-3 Execution

A. CONTRACTOR shall have crews controlled and directed by a landscape foreman well-versed in plant materials, planting, reading blueprints, and coordination between job and nursery, in order to execute installation rapidly and correctly.

B. Product handling:

1. The root balls of plants which cannot be immediately planted shall be protected from wind and sun drying with moist soil or mulch.

2. Trees moved by winch or crane shall be thoroughly protected from chain marks, girdling, or other bark slippage by means of burlap, wood battens, or other approved methods.

3. Container-grown plants shall be carefully removed from the container so as not to disturb the root system. Spades shall not be used to cut containers.

C. Existing conditions:

1. The CONTRACTOR shall verify all site conditions prior to construction.

2. The CONTRACTOR shall exercise care in digging and other work so as not to damage existing utilities or other obstructions. Plantings shall be adjusted to avoid underground or overhead obstructions.

3. The CONTRACTOR shall remove all debris encountered during planting operations from the landscaped area.

D. Job scheduling:

1. In general, work shall proceed as rapidly as the site becomes available.

2. Landscape installation shall not proceed until an adequate on-site source of water is available.

3. CONTRACTOR shall be responsible for coordinating work with other involved parties, including local or State agencies for work conducted on public rights-of-way. CONTRACTOR is responsible for obtaining necessary permits for work conducted on public property, and shall provide permit documents to the ENGINEER for approval prior to submission to the permitting authority.

E. Plantings installation:

1. CONTRACTOR shall excavate circular plant pits with vertical sides as shown on the Plans. Pit diameters shall be at least twice the diameter of the root ball.

2. All plants shall be centered in pits and set on compacted top soil to a depth such that the finished grade level at the plant after settlement will be the same as that at which the plant was grown.

3. Remove burlap from the top of the root ball only. No burlap shall be pulled off the bottom or sides of the rootball. All broken or frayed roots shall be cleanly cut off.

4. Soil shall be backfilled, tamped lightly, and then settled by watering. No filling shall be permitted on top of the root balls.

5. New plantings shall be set so that the final level of ground around the plants shall conform to planned grades.

6. The amount of pruning on new plant materials shall be limited to the minimum necessary to remove dead or injured branches. Pruning shall be in accordance with ANSI A-300 Part 1 and shall be performed in such a manner as to not change the natural habitat or shape of a plant.

7. All plant beds shall be top-dressed with mulch, pine bark, or other materials specified on the project Plans.

8. Temporary staking and other supports:

    a. Plantings shall include temporary straps, stakes, or other supports as indicated on the plans or for non-self-supporting plantings. Plantings shall also include temporary supports to protect plants from damage caused by high winds or other hazards.

    b. Above-ground supports shall consist of flat, grommeted straps staked to the ground using wood or metal stakes, unless otherwise shown on the Plans. Stakes shall be placed at least 18 inches away from the trunk and the straps shall be placed to avoid damage to the trunk. Install flagging on guy lines to help prevent injury. Guy lines should allow a small amount of flexibility to encourage root growth.

    c. Guy lines and stakes shall be removed once the plant is self-supporting and stable.

    d. Underground supports shall consist of wood stakes to stabilize root balls.

F. Sod installation:

1. Moisten prepared surface immediately prior to laying sod.

2. Solid sod shall be laid immediately upon delivery to site with closely abutting joints, with a tamped or rolled even surface. Stagger end joints a minimum of 12 inches.

3. The CONTRACTOR shall bring the sod edge in a neat, clean manner to the edge of all paving and shrub areas.

4. After the sod is laid, a top dressing of clean sand shall be evenly applied over the entire surface and thoroughly washed in.

G. The CONTRACTOR shall fine grade all landscape areas, eliminating all surface irregularities, depressions, sticks, stone, and other debris, and remove them from the site. Rough grading shall be considered as site work per section GA – Grading.

LA-4 Maintenance

A. CONTRACTOR shall maintain all plant materials from the beginning of landscaping until the latter of the final acceptance of the landscaping or final completion of the overall project.

B. Maintenance shall include, but not be limited to: watering of turf and planting areas, mowing, cultivation, weeding, pruning, disease and pest control, replacement of dead or unacceptable materials, straightening turf or planter settlement areas, guy wire repair and tightening, repairing washouts, and any other procedure consistent with good horticultural practice necessary to insure normal, vigorous, and healthy growth of all work.

C. Mowing, if necessary prior to final acceptance, shall occur at regular intervals at a mowing height of 3 inches when the grass reaches a height of 4-1/2 inches with a standard rotary mower. At no time shall more than one third of the leaf surface be removed.

D. The CONTRACTOR shall at all times keep the premises free from accumulations of waste material or rubbish caused by construction activities.

LA-5 Guarantee

A. The CONTRACTOR shall guarantee to replace all plant materials for a period of time after final acceptance as follows:

1. Trees (except palms): 180 days
2. Palms: 1 year
3. Shrubs and ground cover: 60 days
4. Sod: 30 days

B. Should any of the plant materials show 40% or more defoliation during the guarantee period due to the CONTRACTOR's use of improper materials or workmanship, the CONTRACTOR shall, upon written notice, replace the same within 15 days at no additional cost to the COMPANY.

C. Damaged occurring from natural causes, floods, lightning strikes, freezing, winds above 60 mph, improper maintenance on the part of the COMPANY, fires, vandalism, or animals is excluded from this guarantee.

D. This guarantee shall be in effect only if proper maintenance is performed by the COMPANY after final acceptance of the CONTRACTOR's work.

LA-6 Measurement and Payment

A. Trees, shrubs, and other plantings shall be measured and paid per each planting. Work shall include materials, labor, excavation, installation, backfill, fine grading, mulching, staking or guy lines, fertilizers, pruning, guarantee, and maintenance until final acceptance and completion of the project.

B. Sod and other ground covers shall be measured and paid per square yard. Work shall include materials, labor, installation, sand application, fine grading, mulching, fertilizers, guarantee, and maintenance until final acceptance and completion of the project.

END OF SECTION

Section SM – Seeding & Mulching

SM-1 Description

The Work shall consist of preparation of the seed bed, placement of the seed, application of fertilizer and lime and mulching. The CONTRACTOR shall be responsible for seeding and mulching earth slopes and surfaces constructed within the COMPANY's right of way limits unless treated otherwise per plans.

SM-2 Material

A. Seed shall meet the following requirements unless otherwise specified:

1. All seeds shall be furnished from an established seed dealer or certified grower and shall meet all local, State and federal laws and shall be labeled in accordance therewith.

2. The CONTRACTOR shall furnish the ENGINEER all seed labels for the ENGINEER's acceptance prior to placement of the seed. Labels shall show the seed name (kind and variety), the germination test date and percentage, purity of the seed, the percentage of noxious weeds and inert matter and the certification. The seed analysis on the label shall be mechanically printed.

3. The percent purity and percent germination for all seeds shall be at least 95 and 87, respectively.

4. Seed mixtures shall be as specified on plans.

5. Seed mixtures shall be uniformly mixed in the presence of the ENGINEER.

6. Seed mixtures for areas around buildings or fence perimeters to be mowed shall be as shown on the plans or as designated by the ENGINEER.

B. Fertilizer shall meet the following requirements unless otherwise specified:

1. Fertilizer shall be grade 10-10-10 or any acceptable commercial grade fertilizer providing the equivalent amounts of nitrogen, phosphoric acid and potash.

2. Fertilizer shall conform to all State and Federal laws.

3. The material shall be uniform in composition, free-flowing and suitable for application with approved equipment.

C. Lime shall be agricultural grade, dolomitic limestone ground so that a minimum of 85 percent will pass a No. 10 sieve. Lime shall not contain less than 85 percent of calcium carbonate and magnesium carbonate.

D. Mulch shall meet the following requirements unless otherwise specified:

1. Mulch shall be non-toxic to vegetation and contain no growth or germination inhibiting factors.

2. Straw mulch shall conform to the following requirements unless otherwise specified:

   a. Straw mulch shall be air-dried hay or straw.

   b. Material shall not be musty, moldy or otherwise of low quality.

3. Hydraulic mulch shall conform to the following requirements unless otherwise specified:

   a. Hydraulic mulch shall be virgin wood cellulose fibers.

   b. The wood cellulose fibers shall not be water soluble and shall comply with the following properties:

      i. Moisture content (maximum): 15% by weight

      ii. Organic matter, wood fiber (min.): 95% by weight (oven dry basis)

      iii. pH: 4.3 – 8.5

      iv. Water-holding capacity (minimum): 400% by weight (over dry basis)

   c. Material shall be packaged in moisture resistant packages or bags with the net weight of the packaged material plainly shown on each package.

   d. Material shall disperse evenly and rapidly and remain in slurry when agitated with water.

   e. Wood cellulose fiber shall be green in color to allow visual metering of its application and, when sprayed uniformly on the surface applied to, shall form an absorbent cover allowing percolation of water to the underlying surface.

SM-3 Seed Bed Preparation

A. Unless otherwise directed by the ENGINEER, the area to be seeded shall be scarified, disked, harrowed, raked, or otherwise worked until it has been loosened and pulverized to a minimum depth of 3 inches.

B. This operation shall only be performed when the soil is in tillable and workable condition.

C. All stones, boulders, debris and similar material larger than 3 inches in any dimension shall be removed.

D. The prepared surface shall be free of all weeds, clods, stones, roots, sticks, rivulets, gullies, crusting and caking.

E. No seeds shall be sown until seed bed has been approved by the ENGINEER.

SM-4 Fertilizer and Lime Application

A. Fertilizer shall be applied uniformly at the rate shown on Plans, or at 1,500 pounds per acre for commercial grade 10-10-10 fertilizer.

B. Lime shall be applied, separately or in one operation combined with seed and fertilizer at a uniform rate of 2 tons per acre unless directed otherwise.

C. Fertilizer and lime shall be mixed into the top ½ inch of soil with a disk, harrow, rotary tiller or other equipment.

D. Fertilizer and lime need not be worked into the soil as specified above when mixed with seed and water and applied hydraulically.

SM-5 Seeding

A. No seed shall be sown when the soil is frozen, wet, or otherwise untillable or during high winds.

B. Seed mixture and the application rate shall be as shown on Plans.

C. All leguminous seeds shall be inoculated or treated with approved cultures as specified by the manufacturer or as directed by the ENGINEER before sowing or being mixed with other seeds for sowing. Seeds shall be sown within 24 hours after treatment.

D. Seed shall be sown within 24 hours after application of the fertilizer and lime unless applied in one operation.

E. Seed shall be sown uniformly by means of a rotary seeder, wheelbarrow seeder, hydraulic equipment, or other means approved by the ENGINEER.

F. Distribution by hand shall not be allowed except for areas inaccessible to equipment.

SM-6 Straw Mulching

A. Within 24 hours of seeding, straw mulch material shall be uniformly applied at a rate of 2 tons per acre unless the ENGINEER specifies a different rate which takes into account the condition of the mulch material and the topography of the area seeded.

B. Mulch may be spread either by hand, mechanical spreaders, or by blowers.

C. Mulch shall allow sunlight to penetrate and air to circulate but also partially shade the ground and conserve moisture.

D. Mulch shall be held in place by spraying it with a satisfactory liquid asphalt or a emulsified asphalt. The bituminous material may be applied immediately after the mulch

is placed, or it may be injected into the mulch when the mulch is spread with a power-driven spreader. Asphalt applied to the surface of the mulch shall be applied at a rate of 300 gallons per acre and if applied in one operation with the mulch at a rate of 200 gallons per acre. Rates may vary as needed to hold the mulch in place. The CONTRACTOR shall protect any adjacent roadside features such as headwalls, posts, signs and abutments from the bituminous spray. The CONTRACTOR shall not allow bituminous material to flow into any streams, rivers, lakes, or catch basins.

E. Where state or local laws or ordinances prohibit the use of liquid asphalt or emulsified asphalt, alternative products may be approved by the ENGINEER to hold mulch in place. Material may be applied immediately after the mulch is placed or it may be injected into the mulch and the mulch spread by means of a power driven mulch spreader. Application rate shall be as recommended by the manufacturer or as directed by the ENGINEER.

SM-7 Hydraulic Seeding, Fertilization and Mulching

A. Hydraulic equipment shall be used for the application of fertilizer, seed, wood cellulose fiber and water slurry. This equipment shall have a built-in agitation system with an operating capacity sufficient to agitate, suspend and homogeneously mix slurry of the specified amounts of wood cellulose fiber, fertilizer, seed and water. The slurry distribution line shall be large enough to prevent stoppage. The discharge line shall be equipped with a set of hydraulic spray nozzles which will provide even distribution of the slurry. The slurry tank shall have a minimum capacity of 1,000 gallons.

B. Wood cellulose fiber shall be applied at a rate of 1,500 pounds per acre.

C. Fertilizer and lime shall be applied at the rate shown on the Plans or in SM-4.

D. The materials shall be combined in a manner recommended by the manufacturers.

E. All leguminous seeds shall be inoculated or treated with approved cultures as specified by the manufacturer or as directed by the ENGINEER before mixing. Inoculants shall be increased to five times the normal rate recommended by the manufacturer.

F. Slurry mixture shall be so regulated that the amounts and rates of application shall result in a uniform application of all materials at rates not less than the amounts specified.

G. Slurry shall be applied in a sweeping motion, in an arched stream, so as to fall like rain, allowing the wood cellulose fibers to build upon each other until an even coat is achieved.

SM-8 Growth and Coverage

A. Growth and coverage on areas seeded as specified shall be considered to be in reasonably close conformity with the intent of the Contract when the vegetation, exclusive of that from seed not expected to have germinated and shown growth at that time, has reached a point of maturity such that each area shows a satisfactory visible growth with no bare spots larger than six inches square.

B. Bare spots shall be scattered and the total bare areas shall not comprise more than 1 percent of any given area.

SM-9 Restoration or Replacement

A. The CONTRACTOR shall maintain all seeded areas until final acceptance of the project and shall restore or replace, at no cost to the COMPANY, any portion of the seeding work which does not show satisfactory growth and coverage or which becomes damaged prior to final acceptance.

B. Restoration or replacement work shall include the reestablishment of the grade or profile of the area, refertilization, reseeding and remulching as directed by the ENGINEER.

SM-10 Measurement and Payment

A. Measurement

1. Areas that are seeded and mulched shall be measured (along the ground line and/or slope) by the acre by the ENGINEER.

B. Payment

1. Payment for seeding and mulching will be made at the Contract unit bid price for seeding and mulching, which price shall include all necessary material, labor and equipment. Payment shall include all lime, fertilizer, seed, inoculant, mulch and bituminous material supplied and applied by the CONTRACTOR, as well as any ground preparation required.

2. There shall be no separate payment for reseeding or restoring areas that do not show satisfactory growth and coverage or have been damaged.

END OF SECTION

Division III: Pavement Surfaces

Section AP – Asphalt Pavement

Section CP – Concrete Pavement

Section GA – Graded Aggregate

Section RCC – Roller Compacted Concrete

Section AP – Asphalt Pavement

AP-1 Description

The Work shall consist of furnishing and installing asphalt pavement. Asphalt paving shall consist of all hot-mixed, hot-laid mixtures required for leveling, binder, or wearing course construction for new paving or repaving.

Asphalt pavement shall be placed in one or more courses on a prepared base or underlying course in conformity with the lines, grades, thicknesses and typical cross sections as shown on the plans or as established by the ENGINEER.

AP-2 Material

A. Tack coat shall conform to the following material grades:

Type:	Grade:	Application Temperature Range (Degrees F):	AASHTO Specifications:
Emulsified Asphalt	SS-1, SS-1h	75 - 130	M 140
	RS-1, RS-2	110 - 165	M 140
Rapid Curing Cut-Back Asphalt	RC-70	80 - 225	M 81

B. If no grade of tack coat material is specified on the plans, the CONTRACTOR may choose one of the materials specified in paragraph A for tack coat.

C. Asphalt cement for asphalt mixes shall conform to the requirements of AASHTO M 226 for the grade specified on the plans. Grade AC-20 shall be used if grade is not specified on the plans.

D. Coarse aggregate (that retained on a No. 8 sieve) shall meet the following requirements unless otherwise specified:

1. Coarse aggregate shall consist of crushed stone, or crushed or uncrushed gravel.

2. Material shall consist of clean, hard, tough, durable pieces, free from adherent coatings, salts, organic material or friable, thin, elongated pieces.

3. Coarse aggregate shall conform to the requirements of ASTM D 692 and ASTM D 448.

4. Carbonate rock such as limestone or dolomite shall not be used as coarse aggregate for wearing course mixtures unless otherwise approved by the ENGINEER.

E. Fine aggregate (that passing a No. 8 sieve) shall meet the following requirements unless otherwise specified:

1. Fine aggregate shall consist of natural sand or of sand prepared from stone or crushed gravel, or a combination thereof.

2. Material shall consist of hard, tough grains, free of injurious amounts of clay, loam, or other deleterious substances.

3. Fine aggregate shall conform to the requirements of ASTM D 1073.

4. Fine aggregate shall have a minimum sand equivalent value of 35 and 45 for binder and wearing courses, respectively, when tested in accordance with AASHTO T 176.

F. Mineral filler for bituminous slurry surface shall conform to ASTM D 242.

G. Bituminous material for the bituminous slurry surface shall be an Emulsified Asphalt, Type SS-1h, or a Catonic Emulsified Asphalt, Type CSS-1h, conforming to the requirements of AASHTO M 140 and AASHTO M 208, respectively.

H. The use of heat-stable anti-stripping agents shall be in accordance with the manufacturer's recommendations, but in no case shall it exceed a maximum of 1.0 percent or be less than 0.3 percent by weight of the asphalt cement. Such agents shall contain no ingredients harmful to the asphalt cement and shall not appreciably alter the specified characteristics of the bituminous material.

I. Substitution of local materials (such as processed reef shell) shall be subject to the approval of the ENGINEER.

J. Paving fabric (asphalt overlay textile) shall conform to Section EF - Engineering Fabric of these Specifications.

AP-3 Composition of Mixes

A. The following table shows acceptable gradations and mix designs which shall be used. The CONTRACTOR may choose from one or more mixes (subject to the following requirements) when no mix is shown on the plans. In addition, established State Highway Department mixes meeting the recommended criteria may be substituted subject to the approval of the ENGINEER.

In general, mix designs 2A - 5A shall be used for level or binder courses. Mix designs 5A - 8A shall be used for wearing courses.

	Asphalt Concrete					Sand Asphalt	Sheet Asphalt
	Mix Designation and Nominal Maximum Size of Aggregate						
Sieve Size	1-1/2 in.	1 in.	3/4 in.	½ in.	3/8 in.	No. 4	No. 16
Mix Design	2A	3A	4A	5A	6A	7A	8A
Grading of Total Aggregate (Coarse Plus Fine, Plus Filler If Required) Amounts Finer Than Each Laboratory Sieve (Square Openings) Weight %							
2-1/2 in.	...	...	...	...	...	...	...
2 in.	100	...	...	...	...	...	...
1-1/2 in.	90 to 100	100	...	...	...	...	...
1 in.	...	90 to 100	100	...	...	...	...
3/4 in.	56 to 80	...	90 to 100	100	...	...	...
½ in.	...	56 to 80	...	90 to 100	100	...	...
3/8 in.	...	...	56 to 80	...	90 to 100	100	...
No. 4	23 to 53	29 to 59	35 to 65	44 to 74	55 to 85	80 to 100	100
No. 8	15 to 41	19 to 45	23 to 49	28 to 58	32 to 61	65 to 100	95 to 100
No. 16	...	...	...	...	...	40 to 80	85 to 100
No. 30	...	...	...	...	...	25 to 65	70 to 95
No. 50	4 to 16	5 to 17	5 to 19	5 to 21	7 to 23	7 to 40	45 to 75
No. 100	...	...	...	...	...	3 to 20	20 to 40
Asphalt Cement, Weight Percent of Total Mixture							
%	3 to 8	3 to 9	4 to 10	4 to 11	5 to 12	7 to 12	8 to 12
Suggested Coarse Aggregate Sizes							
	4 and 67 or 4 and 68	5 and 7 or 57	67 or 68 or 6 and 8	7 or 78	8		

B. Mixes designed for level or binder courses shall use either No. 2 or No. 3 gradation of fine aggregate as listed in the mix table below to be combined with a grade of coarse aggregate. No. 4 gradation may also be used for the coarse and fine aggregate for the wearing courses consisting of sheet asphalt (8A) or sand asphalt (7A).

Gradation Requirements for Fine Aggregate **Amounts Finer Than Each Laboratory Sieve (Square Openings), Weight %**				
Sieve Size	**Gradation No. 1**	**Gradation No. 2**	**Gradation No. 3**	**Gradation No. 4**
3/4 in.	100	100	...	...
No. 4	80 to 100	95 to 100	100	100
No. 8	65 to 100	70 to 100	75 to 100	95 to 100
No. 16	40 to 80	40 to 80	50 to 74	85 to 100
No. 30	20 to 65	20 to 65	28 to 52	65 to 90
No. 50	7 to 40	7 to 40	8 to 30	30 to 60
No. 100	2 to 20	2 to 20	0 to 12	5 to 25
No. 200	0 to 10	0 to 10	0 to 5	0 to 5

C. Pavement shall have a minimum stability factor of 1,500 pounds when designed by the Marshall Method and tested in accordance with ASTM D 1559. The percent air voids shall range from 3-8 for binder courses and 3-5 for wearing courses. Flow shall range from 8-16 units (unit = 0.01 inch).

D. The use of mineral filler if needed to meet the required mixture stability shall not exceed 5 percent by weight of the total mixture.

AP-4 Documentation, Testing and Acceptance

A. Acceptance testing of asphalt pavement shall be the responsibility of the COMPANY.

B. The CONTRACTOR shall furnish the mix design to the ENGINEER for approval. The mix design shall specify:

1. Mix producer and location.

2. Mix designation or type as outlined in subsection AP-3 of this Section.

3. Type and gradation of aggregate.

4. Type and grade of asphalt cement.

5. Percent of bitumen based on the total weight of the mixture, exclusive of water and solvents.

C. The COMPANY shall sample and test individual materials on a random basis. Conformance with Specification requirements, continuous uniformity and proper workability of the mixture shall determine the acceptance of the mixtures.

D. Acceptance of mixtures for gradation, crushed particle content and bitumen shall be determined on the basis of random extractions and gradation tests performed by the COMPANY.

E. Acceptance of mixture for compaction shall be determined on the basis of density tests performed on a random basis by the COMPANY.

F. The COMPANY shall perform testing required to determine the minimum stability factor.

G. The COMPANY shall furnish the results of tests performed to the CONTRACTOR. If the CONTRACTOR does not agree with the COMPANY's test results, he may request in writing to the COMPANY that additional tests be made. The written request shall include the CONTRACTOR's test results. Upon receipt and approval of the written request for additional testing, the COMPANY shall perform one additional test for the particular test in question.

H. Asphalt pavement in place not meeting the material specification, mix design or density test shall be removed and replaced by the CONTRACTOR at no cost to the COMPANY.

AP-5 Equipment

A. Equipment and tools necessary for handling materials and performing all parts of the Work shall be approved by the ENGINEER as to design, capacity and mechanical condition. The equipment shall be at the jobsite sufficiently ahead of the start of construction operations to be examined. Any equipment not maintained in satisfactory working order, or which is proved inadequate, shall be improved or new equipment substituted, as directed by the ENGINEER.

B. Asphalt mixing plants shall be of either the batch-type or the continuous mixing type (which includes the dryer-drum mixing plant) and must be capable of producing a uniform mixture within the job-mix tolerances.

C. Asphalt pavers shall meet the following requirements:

1. Pavers shall be self-contained, power-propelled units provided with an activated screed or strike-off assembly, heated if necessary, and capable of spreading and finishing asphalt mix in lane widths applicable to the specified typical section and thickness as shown on the plans or as established by the ENGINEER.

2. Pavers shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed, or strike-off assembly.

3. The screed or strike-off assembly shall produce effectively a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

4. When laying mixtures, the paver shall be capable of operation at forward speeds consistent with satisfactory laying of the mixture.

5. Paver shall be capable of smoothing and adjusting all longitudinal joints between adjacent strips or courses of the same thickness.

6. Paver shall be equipped with a mechanical device to be able to adjust to grade so that minor changes in elevation will not be reflected in the finished surface and that the paver will confine the edges of the mixture to the true lines.

7. Equipment used for shoulder and similar construction shall be capable of spreading and finishing the courses in widths shown on the plans.

D. Compaction equipment shall meet the following requirements:

1. Compaction equipment shall consist of steel-wheel, pneumatic tire or vibratory rollers, or any combination of the three.

2. All rollers shall be self-propelled and in satisfactory working condition and be capable of reversing without backlash.

3. Steel-wheel rollers shall be equipped with scrapers.

4. Steel-wheel rollers may be of three types; three-wheel rollers of 10 to 12 tons in weight, two-axle tandem rollers of 8 to 12 tons in weight, and three-axle tandem rollers of 12 to 18 tons in weight.

5. Pneumatic tire rollers shall be of the oscillating type and equipped with smooth tires of equal size, diameter and ply rating. Minimum contact pressure shall be 85 psi. Wobble-wheel rollers shall not be permitted.

6. All rollers shall have a system for moistening each wheel or roll with water or a water-detergent solution to prevent adhesion of the mixture.

7. In areas inaccessible to power-driven steel-wheel rollers or pneumatic tire rollers, power driven trench rollers, tampers or other suitable equipment may be used.

E. Trucks used for hauling asphalt mixtures shall meet the following requirements:

1. Trucks shall have tight, clean, smooth, metal beds which have been thinly coated with a water-detergent solution, paraffin oil, a lime-water solution, or a commercial release agent to prevent the mixture from adhering to the beds. The use of kerosene or similar products will not be permitted.

2. Trucks shall be in good mechanical condition. No trucks shall be used which cause segregation of materials because of faulty spring suspension, or other faults; which show large oil leaks; or which cause undue delay in delivery of material.

3. Each truck shall be covered by a tarpaulin or other suitable cover which will protect the mixture from moisture and foreign matter and prevent the rapid loss of heat during transportation.

4. When necessary to maintain the specified temperature until discharge at the job site, truck bodies shall be insulated and covers securely fastened.

F. Distributors used for application of tack coats shall meet the following requirements:

1. Distributors shall be of the pressure-type, except that a hand spray bar may be used in areas inaccessible to a distributor.

2. Distributor shall be equipped with properly working pressure gauges, thermometer and spray bars.

3. Distributor shall be capable of applying material in controlled rates of from 0.05 to 2.0 gallons per square yard under a uniform pressure. The variation from a specified rate shall not exceed 0.02 gallon per square yard.

4. Distributor shall be operated so that the bituminous material is heated evenly and applied uniformly on variable widths of surfaces up to 15 feet.

G. Slurry mixing machines shall meet the following requirements:

1. The slurry mixing machine shall be a continuous flow mixing unit, truck mounted, capable of delivering accurately, predetermined, properly proportioned amounts of aggregate, water and emulsified asphalt to an approved mixing unit and to discharge the thoroughly mixed product on a continuous flow basis.

2. The machine shall have sufficient storage capacity for aggregate emulsified asphalt, mineral filler and water to maintain an adequate supply to the proportioning controls. Sufficient machine storage to mix properly and apply a minimum of eight tons of aggregate without the use of auxiliary trucks and tanks shall be provided.

3. The machines shall be fully powered so as to produce and spread slurry of an acceptable and uniform consistency without the addition of excessive water.

4. The machine shall be equipped with an approved fines feeder that shall provide a uniform, positive, accurately metered, predetermined amount of the specified mineral filler at the same time and location that the aggregate is fed.

5. The machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray to the road surface immediately ahead of the slurry spreading equipment.

6. The CONTRACTOR shall have multiple machines to assure high production.

H. Slurry spreading equipment shall meet the following requirements:

1. A squeegee distributor box shall be attached to the slurry mixing machine. The distributor shall be equipped with flexible material in contact with the surface to prevent loss of slurry from the distributor box. The rear flexible seal shall be adjusted to width. It shall be maintained so as to prevent loss of slurry on varying grades and crown by adjustments to assure uniform spread.

2. The box shall be equipped with a steering device and shall be kept clean and free of any build-up of asphalt and aggregate.

3. A burlap drag may be required by the ENGINEER to obtain the desired texture.

4. Additional equipment may consist of a power broom or blower and any other necessary tools.

AP-6 Surface Preparation

A. Surfaces to be paved shall be true to line and grade and contain no depressions or soft spots.

B. Prior to paving, all loose material, silt spots, vegetation, or other foreign material shall be removed from the existing surface and cracks.

C. The surface shall be free of ice and snow.

D. Existing surfaces that are warped or irregular shall be brought to a uniform grade and cross section by use of a leveling mixture. In addition, all holes and depressions within the existing pavement shall be patched and compacted to a tight surface conforming to the surrounding area. All such areas that are unstable shall be removed and backfilled with crushed stone before patching. Excavation of holes and/or depressions for patching shall have vertical sides and sharp corners. Patching and leveling materials shall consist of one of the specified binder mixtures.

E. A soil sterilant shall be applied to cracks in existing asphalt pavement surfaces prior to the installation of any paving fabric or application of tack coat. Application shall be in accordance with the manufacturer's recommendations.

F. Paving fabric shall be installed as shown on the plans or as directed by the ENGINEER. Installation shall be in accordance with Section EF - Engineering Fabric of these Specifications.

G. As noted on Plans, tack coats shall be applied to all asphalt surfaces as follows:

1. Tack coat shall be applied to all asphalt surfaces prior to application of next asphalt pavement layer, regardless of when previous layer was completed, at a rate between 0.05 and 0.15 gallons per square yard. Surface must be swept clean of all loose dirt, clay, or other objectionable materials prior to application. No more tack coat shall be applied that can be covered with asphalt paving during daylight hours of the same day that the tack coat was applied. No vehicles or equipment, other than pavers and asphalt delivery trucks shall be allowed on the tack coat. Asphalt delivery trucks shall be routed to a staging area to prevent tracking of excessive dust or loose materials on the tack coat. Tack coat which loses its adhesiveness due to dust or other foreign matter shall be replaced by the CONTRACTOR at no expense to the COMPANY.

2. Where the tack coat is applied adjacent to curbs, gutters, valley gutters, sign posts, foundations, or other surfaces not to be paved, such surfaces shall be covered with heavy building paper or otherwise protected as approved by the ENGINEER while the tack coat is being applied. Any bituminous material deposited on such surfaces shall be removed. An exception would be where contact surfaces shall be painted with a uniform layer of the bituminous material before paving.

3. The CONTRACTOR shall exercise caution to prevent tack coat materials from entering waterways or drainage systems due to runoff.

4. The CONTRACTOR shall be responsible for the protection of the tack coat from traffic until the subsequent layer of asphalt paving is placed. Damaged tack coat shall be replaced by the CONTRACTOR at no expense to the COMPANY.

AP-7 Weather Limitations

A. Tack coats shall not be applied to any wet or frozen surface.

B. Asphalt paving shall be performed only when the material can be placed such that it attains its full strength.

C. Mixtures may not be placed on frozen surfaces, excessively wet surfaces, or when pending weather conditions would otherwise prevent its proper placement and compaction.

D. Tack coats and asphalt mixtures shall not be placed when either the air temperature or the temperature of the surface on which the material is to be placed is below 40°F.

E. Rolling and finishing operations shall be completed during daylight hours.

F. The CONTRACTOR shall make no claims against the COMPANY for delays due to unfavorable weather conditions.

AP-8 Construction Procedure

A. Asphalt mixture shall be placed while the mixture temperature range is between a minimum of 250°F and a maximum of 325°F.

B. Except for leveling courses, the mixture shall be unloaded into the mechanical hopper and spread by a mechanical paver in the layers and compacted depth specified on the plans or as specified by the ENGINEER.

C. The mixture shall be free from lumps and shall be spread while still in a workable condition. Hand placement shall be allowed only in those areas inaccessible to the paver.

D. Spreading for leveling courses may be accomplished by means of a motor patrol following a spreader.

E. Placement shall be as continuous as possible.

F. The surface shall be rolled after the asphalt mixture has been spread, struck-off and surface irregularities adjusted. The mixture shall be in the proper condition so that rolling does not cause undue displacement, cracking, or shoving. The number, weight and type of roller used shall be sufficient to obtain the required compaction while the mixture is in a workable condition. Unless otherwise directed, rolling shall begin at the sides and proceed longitudinally parallel to the center of the pavement, each trip overlapping at least ½ the roller width. When abutting a previously placed lane, the longitudinal joint shall be rolled first, followed by the regular rolling procedure. Asphalt concrete shall be compacted to an average density of not less than 93 percent of the maximum theoretical density as determined by AASHTO T 209.

G. The finished surface of the binder course shall not vary more than ¼ inch, and the finished surface of the wearing course shall not vary more than 1/8 inch, as measured from the bottom of a 10 foot straightedge laid across the pavement after compaction.

H. Final rolling shall continue until all roller marks are eliminated.

I. Outside edges of pavement area shall be compacted and rounded from the new pavement and to the existing base surface.

J. Any raveling or cracking along edges shall be repaired by the CONTRACTOR at no expense to the COMPANY.

AP-9 Joints

A. Joints between old and new pavements, or between successive days work shall be made so as to ensure thorough and continuous bond between the old and new mixtures.

B. Longitudinal and transverse joints shall be made in a careful manner and shall present the same texture and smoothness of other sections of the course. Edges that have adjacent paving shall be compacted with a near vertical face.

C. Longitudinal joints in sucessive pavement layer shall be staggered a minimum of 6". For areas where a defined travel lanes is desired, the longitudinal joint in the wear surface shall occur at the lane line.

D. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. A brush coat of asphalt material shall be used on contact surfaces of transverse joints just before additional mixture is placed against previously rolled material.

AP-10 Bituminous Slurry Surface

A. No coal tar shall be allowed.

B. Bituminous slurry surface shall be uniformly placed on existing pavement at locations as shown on the plans or as directed by the ENGINEER.

C. Bituminous material shall conform to the requirements of subsection AP-3 of this Section.

D. Stone aggregate shall conform to mix designs 7A or 8A as previously specified in subsection AP-3 of this Section.

E. Water used with the slurry mixture shall be potable and free of harmful soluble salts. A minimum amount of water shall be added as necessary to obtain a fluid and homogeneous mixture. Total time of mixing shall not exceed 4 minutes.

F. Prior to placement of the slurry coat, the CONTRACTOR shall sweep the surface with a power broom removing all dirt, debris and loose material. All cracks shall be cleaned to a depth of 1 inch by using power brooms, compressed air, high pressure water, or any other method approved by the ENGINEER. Water flushing shall not be permitted in areas where considerable cracks are present in the pavement surface.

G. The residual asphalt content shall range from 7.5 percent to 13.5 percent by weight, of the dry aggregate, with final blend to be determined by the ENGINEER.

H. The surface shall be fogged with water immediately preceding slurry application at the maximum rate of 0.05 gallons per square yard.

I. Slurry shall be spread using an approved slurry mixer equipped with a mechanical type squeegee distributor. Other squeegees may be used in inaccessible areas, if approved in advance by the ENGINEER. Care shall be taken in leaving no unsightly appearance from hand work.

J. Rate of application shall be a minimum of 10 pounds per square yard.

K. Slurry shall not be applied if either the pavement or ambient temperature is 55°F or less and falling, but may be applied when both the ambient and pavement temperature are 45°F or above and rising. Whenever the relative humidity exceeds 80 percent or the weather is overcast, the application of the slurry shall be at the direction of the ENGINEER.

L. Finished surface shall have a homogenous appearance and be free of streaks, lumping, or excessive build-up. Cured slurry shall fill all cracks, adhere firmly to the existing surface, and have good skid resistance texture.

M. Treated areas shall be allowed to cure before exposed to traffic.

N. Any damage to uncured slurry shall be the responsibility of the CONTRACTOR.

AP-11 Compacted Stone Shoulders

A. CONTRACTOR shall use crushed stone material as specified in Section GA - Graded Aggregate of these Specifications for placement as compacted shoulder on newly paved asphalt areas.

B. Slope and length of shoulders shall conform to the typical section shown on the plans or as directed by the ENGINEER.

C. Rolled compaction shall be even and smooth with the edge of the asphalt and tapering to the outer shoulder of the subbase.

AP-12 Measurement and Payment

A. Measurement

1. Asphalt quantities for use in new paving or repaving shall be determined by the ENGINEER. Measurement of the asphalt mixture placed shall be by the number of tons placed as determined from CONTRACTOR supplied weight tickets, by the number of finished square yards placed as measured by the ENGINEER, or as otherwise shown on the bid sheet.

2. Paving fabric shall be measured in accordance with Section EF - Engineering Fabric of these Specifications.

3. There shall be no separate measurement for soil sterilant applied.

4. Crushed stone used in shoulder construction shall be measured in accordance with Section GA - Graded Aggregate of these Specifications.

5. Measurement of the bituminous slurry shall be determined by the number of square yards placed as measured by the ENGINEER.

6. Milling of existing pavement shall be measured per square yard milled as measured by the ENGINEER.

7. All linear and surface area measurements shall be based on planimetric measurements (two-dimensional planar surface projection). No allowance shall be made for pavement cross-slopes, crowns, or other vertical features.

B. Payment

1. Payment for new asphalt pavement will be made at the Contract unit bid price of new asphalt pavement, which price shall include all necessary material, labor and equipment. Payment shall also include preparation of roadbed for new paving such as leveling the surface or proof rolling.

2. Payment for asphalt provided for overlays, leveling, or patching will be included in the Contract unit bid price for repaving asphalt, which price shall include all necessary material, labor and equipment. Payment shall also include the removal of any defective or broken asphalt pavement, sweeping the existing pavement and the application of a tack coat.

3. Payment for undercutting an unsatisfactory subgrade and backfilling with crushed stone will be in accordance with Section GR - Grading and Section GA - Graded Aggregate, respectively, of these Specifications.

4. Payment for crushed stone used as a base course or for shoulder construction will be made in accordance with Section GA - Graded Aggregate of these Specifications.

5. Payment for installation of paving fabric will be made in accordance with Section EF - Engineering Fabric of these Specifications.

6. Payment for the placement of bituminous slurry will be made at the Contract unit bid price per square yard of bituminous slurry placed, which price shall include all necessary material, labor and equipment including preparation of the existing surface.

7. Payment for milling shall be made at the Contract unit price per square yard of milling area. The price shall include all equipment, material, transport, and labor. The price shall also include disposal of millings unless otherwise directed by the ENGINEER or on the Plans.

8. No separate payment will be made for the following:

    a. Testing performed by the CONTRACTOR.

    b. Replacing asphalt in connection with the installation of utilities, conduit, or drainage. Payment for the required asphalt shall be included in the payment for the installation of utilities, conduit, or drainage.

END OF SECTION

Section CP – Concrete Pavement

CP-1 Description

The Work shall consist of furnishing and installing concrete pavement including dolly pads and miscellaneous slabs as shown on the plans. Concrete pavement shall be placed on a prepared subbase in conformity with the lines, grades, thicknesses and typical cross sections as shown on the plans or established by the ENGINEER.

CP-2 General Conditions

A. The CONTRACTOR shall furnish and deliver to the jobsite the required materials specified on the plans or in these Specifications. The CONTRACTOR shall unload and stockpile materials in an orderly manner at locations designated by the ENGINEER.

B. Materials shall be protected from damage due to weather. No deteriorated or damaged material shall be used.

C. The CONTRACTOR shall protect the pavement against traffic. This shall include flaggers to direct traffic and erection and maintenance of standard warning signs and lights. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at no expense to the COMPANY.

D. In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the CONTRACTOR shall be required to have available at all times materials for the protection of the edges and surface of the unhardened concrete. For protection of the pavement edges, such material shall consist of standard metal forms or wood plank, which has a nominal thickness of no less than 2 inches and a nominal width of no less than the thickness of the pavement at its edges. Covering material such as burlap, cotton mats, curing paper, or plastic sheeting shall be provided for the protection of the pavement surface. When rain appears imminent, paving operations shall stop. All available personnel shall be used to protect the pavement.

E. Water shall not be allowed to pond on the new pavement surface.

CP-3 Material

A. Cement shall be Type IA or IIIA air-entrained Portland cement and conform to the requirements of AASHTO M 134. The type of cement shall be as shown on the plans or as specified by the ENGINEER.

B. Air-entraining admixture shall be of the neutralized vinsol resin type and conform to the requirements of ASTM C 260. The percentage of air-entrainment shall be as shown on the plans or as specified by the ENGINEER.

C. Admixtures, except air-entraining agents, used to alter the normal properties of concrete shall be used only upon the approval of the ENGINEER and conform to the requirements

of ASTM C 494. Chemical admixtures for flowable concrete shall conform to the requirements of ASTM C 1017.

D. Coarse and fine aggregate shall conform to the requirements of AASHTO M 80 and AASHTO M 6, respectively, and meet the following requirements:

1. Do not use aggregate containing particles that are reactive with alkalis, including opaline, unless ASTM C 1260 test results show less than 0.10% expansion in 16 days and low alkali cement (less than 0.6% alkali) is used.

2. Gradation shall meet the requirements shown in subsection CP-5. Gradation shall also meet the requirements of ASTM C 33 for fine aggregate and ASTM C 33 Table 2 for coarse aggregate.

3. Aggregate shall meet the following impurities limits:

Description:	Maximum Percent by Weight	
	Fine	Coarse
Clay lumps	1.0%	0.25%
Coal and lignite	1.0%	0.25%
Alkali	Trace	Trace
Material finer than a No. 200 sieve	4.0%	0.5%*
Other deleterious substances (such as shale, mica, coated grains, soft and flaky particles)	3.0%	-
Soft fragments	-	2.0%
Other deleterious substances (such as friable, thin, elongated, or laminated pieces)	-	1.0%

** When the material finer than the No. 200 sieve consists essentially of crusher dust, the maximum amount permitted shall be 1.5 percent.*

E. Water shall meet the following requirements:

1. Water shall be reasonably clear and free from oil, salt, sugar, acid, alkali, organic and other injurious substances.

2. Water shall be tested in accordance with and meet the requirements of AASHTO T 26 unless known to be of potable quality.

3. Water shall not contain impurities in excess of the following limits:

   a. Acidity or alkalinity (as $CaCO_3$): 0.05%

   b. Total organic solids: 0.05%

   c. Total inorganic solids: 0.05%

4. Where the source of water is relatively shallow, the intake shall be so enclosed to exclude silt, mud, grass, or other foreign materials.

5. Non-potable water may be used if mortar cubes made with the water in question have 7 and 28 day strengths equal to at least 90 percent of similar specimens made with the sand cement and potable water. Testing shall conform to the requirements of AASHTO T 71.

F. Reinforcing bars shall meet the following requirements:

1. Bars shall be intermediate grade, new deformed billet steel, conforming to the requirements of ASTM A 615, Grade 40 or 60.

2. Size, grade, shape and length shall be as shown on the plans.

3. Bars shall be free from dirt, paint, oil, grease, thick rust and other foreign substances.

4. Reinforcing bars shall be accurately cold bent to the shapes and dimensions specified. The minimum bend diameter shall be as shown in the table below, except that for sizes No. 3 to No. 11, inclusive, Grade 40 bars, the minimum diameter shall be 5 bar diameters.

   a. Bar sizes No. 3 through No. 8: 6 bar diameters minimum (Grade 60)

   b. Bar sizes No. 9 through No. 11: 8 bar diameters minimum

   c. Bar sizes No. 14 and No. 18: 10 bar diameters minimum

5. Bars shall be bent in the plane for which they were designed. Maximum allowable deviation for No. 7 bars and under shall be 1/2 inch out of plane and for No. 8 bars and over 1 inch out of plane.

6. Reinforcement supports shall be all plastic or all stainless steel.

G. Dowel bars for transverse expansion joints shall meet the following requirements:

1. Dowel bars shall be plain round bars of the grade and size as shown on the plans and conform to the requirements of AASHTO M 31 or M 42.

2. Bars shall be smooth, round and have all cutting burrs, loose mill scale, rust, grease and oil removed.

3. Before installation, each dowel bar shall be painted with one coat of industrial grade zinc base primer, epoxy, or other approved rust inhibitive primer.

H. Metal sleeve or tube assembly for transverse expansion joints shall be of an approved design, mortar tight, of sufficient length to prevent collapse and at least 4 inches in length.

I. Tie bars shall meet the following requirements:

1. Tie bars shall be deformed bars of the grade and size as shown on the plans and conform to the requirements of AASHTO M 31 or M 42.

2. Bars shall be smooth, round and have all cutting burrs, loose mill scale, rust, grease and oil removed.

J. Anchor bolts shall be of the type and of the diameter as shown on the plans.

K. Epoxy bonding compound shall conform to the requirements of ASTM C 881, Type II, Grade 1 or 2, and shall be subject to the approval of the ENGINEER.

L. Water stop shall be polyvinyl chloride (PVC) made from virgin raw materials and shall conform to the requirements of the U.S. Army Corps of Engineers Specification CRD C 572.

M. Grout for anchor bolt and dowel placement shall be non-shrink, non-metallic and conform to the requirements of ASTM C 1107 and CRD C 632, Grade B. The minimum compressive strength after 28 day shall be 5,000 psi.

N. Non-epoxy bonding compound shall conform to ASTM C 1059 Type II. Compound shall be only used when joining new to existing concrete where bonding compound cannot be placed immediately prior to pouring new concrete.

O. Preformed expansion joint filler shall conform to the requirements of ASTM D 1751.

P. Curing coverings shall meet the following requirements:

1. Coverings may consist of hay, straw, burlap, liquid membrane-forming compounds, white polyethylene sheeting, or waterproof paper.

2. Hay or straw must be free of objects such as sticks, stones, or ingredients that might damage or discolor the concrete surface.

3. Burlap shall conform to the requirements of AASHTO M 182, Class 3 or 4.

4. Liquid membrane-forming compounds shall conform to the requirements of AASHTO M 148, Type 2 (white pigmented). Type 1 (clear or translucent) may be used when shown on the plans or as directed by the ENGINEER.

5. Polyethylene sheeting shall be white opaque and conform to the requirements of AASHTO M 171.

6. Waterproof paper shall be white and conform to the requirements of AASHTO M 171.

Q. Joint sealing compound shall meet and/or exceed ASTM D 5893-96 "Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements," Type NS (Non-Sag).

R. Backer rod shall be closed-cell, expanded polyethylene foam rod.

S. Steel welded wire fabric shall meet the following requirements:

1. Fabric shall conform to the requirements of AASHTO M 55.

2. Wire spacing and size shall be as shown on the plans.

3. All fabric shall be free from dirt, paint, oil, grease, thick rust and other foreign substances.

4. It shall be permissible for the CONTRACTOR to furnish longitudinally hinged wire fabric for sheets of a required width of 8 feet or greater. The hinge shall be made by looping the transverse wires around a longitudinal wire and shall be capable of developing the full strength of the transverse wire. The hinge shall be located within 12 inches of the center of the width of the sheet.

5. Fabric may be spliced by overlapping the sheets not less than 12 inches.

T. Materials shall be installed in accordance with the manufacturer's recommendations.

CP-4 Equipment

A. Equipment and tools necessary for handling materials and performing all parts of the Work shall be approved by the ENGINEER as to design, capacity and mechanical condition. The equipment shall be at the jobsite sufficiently ahead of the start of construction operations to be examined. Any equipment not maintained in satisfactory working order, or which is proved inadequate, shall be improved or new equipment substituted, as directed by the ENGINEER.

B. Batching plant equipment shall meet the following requirements:

1. The batching plant shall include bins, weighing hopper and scales for fine aggregate and for each size of coarse aggregate.

2. If cement is used in bulk, a separate bin, hopper and scale for cement shall be included. The weighing hopper shall be properly sealed and vented to preclude dusting during operation.

3. Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

4. Scales for weighing aggregates and cement shall meet the following requirements:

a. The scales for weighing aggregates and cement shall be inspected, approved and sealed in accordance with the requirements of the appropriate state or local regulating agency.

b. Scales shall be inspected and sealed as often as the ENGINEER may deem necessary to assure their continued accuracy. The CONTRACTOR shall have on hand not less than 50 pound weights for frequent testing of all scales.

c. Batching plants equipped to proportion aggregates and bulk cement by means of automatic weighing devices may be used.

5. Water measuring equipment shall meet the following requirements:

a. Unless the water is weighed, the water measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled.

b. The measuring tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided to readily and accurately determine the amount of water in the tank.

c. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

6. A positive, automatic mechanical method shall be used for adding admixtures in solution.

7. Mixers at the jobsite or at a central location shall meet the requirements of subsection CP-7 of this Section.

C. Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central mixed concrete shall conform to the requirements of AASHTO M 157.

D. Non-agitator trucks shall meet the following requirements:

1. Bodies of non-agitating trucks hauling concrete shall be smooth, mortartight, metal (non-aluminum) containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation.

2. The concrete shall be discharged from the bottom of the container. If discharge is accomplished by tilting the body, the surface of the load shall be retarded by a suitable baffle.

3. Covers shall be provided when needed for protection.

E. The finishing machine shall be designed and operated to strike off, consolidate and obtain a smooth finish. The top of the forms, if used, shall be kept free from accumulation by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true.

F. Vibrators shall meet the following requirements:

1. For full width vibration of concrete pavement, vibrators may be either the surface pan type or the internal type with either immersed tube or multiple spuds.

2. They may be attached to the spreader or the finishing machine, or may be mounted on a separate carriage.

3. Vibrators shall not come into contact with joint, load transfer devices, subgrade, or side forms.

4. The frequency of surface vibrators shall not be less than 3,500 impulses per minute, and the frequency of the internal type shall not be less than 5,000 impulses per minute for tube vibrators and shall be not less than 7,000 impulses per minute for spud vibrators.

5. When spud type internal vibrators, either hand operated or attached to spreaders or finishing machines, are used adjacent to forms, they shall have a frequency of not less than 3,500 impulses per minute.

6. Vibration of concrete shall not exceed 10 seconds at any one location.

7. Other types of vibrators may be used when shown that they perform the function intended.

G. Concrete saws shall meet the following requirements:

1. The CONTRACTOR shall provide sawing equipment, adequate in number of units and power to complete the sawing of joints to the dimensions as shown on the plans and at the required rate for preventing uncontrolled cracking.

2. A standby saw and ample supply of saw blades shall be maintained at the jobsite at all times during sawing operations.

H. Forms shall meet the requirements of subsection CP-11 of this Section.

CP-5 Composition of Mixes

A. The following concrete mix table shall be used as a guide with exact quantities to be determined by the CONTRACTOR to take into account local variation in materials. In addition, established state highway department mixes meeting the recommended criteria may be substituted subject to the approval of the ENGINEER.

Concrete Mix Table						
Class of Concrete	Min. 28-Day Compressive Strength (PSI)	Coarse Aggregate Size No.*	Cement (Sacks/C.Y. of Concrete)	Max. Water-Cement Ratio (Gals./Sack)	Maximum Slump (in.)	Maximum Air Content (% Volume)
A50-A	5,000	57, 67, 68	7.18	4.97	4	2.5 - 6.0
A45-A	4,500	56, 57, 67	7.18	5.19	4	2.5 - 6.0
A40-A	4,000	56, 57, 68	6.76	5.30	4	4.0 - 8.0
B35-A	3,500	56, 57, 69	6.76	5.19	4	3.5 - 7.0
B30-A	3,000	57	6.60	5.50	4	3.0 -5.0
B30	3,000	57	6.60	6.00	4	0
C	2,000	57	5.40	6.75	4	0

** Size No. per AASHTO M 43*

B. As an alternate to the Concrete Mix Table, the CONTRACTOR may supply a concrete mix design meeting the specified concrete strength. An alternate mix design shall be approved by the ENGINEER before use. Alternate mix designs shall be determined as follows:

1. Method 1 - Without preliminary strength test.

   a. If suitable data from trial batches or field experience is not available, permission may be granted to base concrete proportions on the water-cement ratios shown in the following table.

Minimum 28-Day Compressive Strength (PSI)*	Maximum Permissible Water-Cement Ratio (Gals./Sack)	
	Non-Air-Entrained Concrete:	Air-Entrained Concrete:
5,000	3.5	**
4,500	4.29	3.39
4,000	4.97	3.95
3,500	5.76	4.51
3,000	6.55	5.19
2,500	7.33	6.09
2,000	8.12	7

** 7 day strengths for Type III and IIIA concrete.*

*** For compressive strengths above 4,500 psi for air-entrained concrete, proportions shall be selected by Method 2.*

2. Method 2 - With preliminary strength tests.

   a. Water-cement ratios, other than those shown in the table above, may be used when preliminary test results or field data is available.

   b. Proportions shall be selected to produce a required compressive strength exceeding the specified compressive strength as outlined in the current editions of "ACI 318" and "ACI 214" or as follows:

i. A curve shall be established showing the relationship between the water-cement ratio and compressive strength. The curve shall be established by plotting at least three points representing batches which produce strengths above and below that required with each point representing the average of at least three test specimens tested at 28 days or the earlier age designated.

ii. The maximum water-cement ratio for the required compressive strength shall be that shown by the curve to produce a strength 15 percent greater than the specified strength.

3. For alternate mix designs, the following air contents, when air-entrained concrete is required, shall be adhered to:

Maximum Size Coarse Aggregate (Inches)	Air Content (% by Volume)
1-1/2, 2 or 2-1/2	5 ± 1
3/4 or 1	6 ± 1
3/8 or 1/2	7 ± 1

4. An alternate mix design may be approved by the ENGINEER without preliminary testing if such mix is in close conformity to approved mixes.

C. Concrete that is subject to freezing temperatures while wet shall have a maximum water-cement ratio of 5.98 by volume and shall be air-entrained.

CP-6 Measurement of Materials

A. Bulk cement is required for all uses unless the ENGINEER permits the use of bag cement. Cement shall be measured by weight to an accuracy of plus or minus 1 percent.

B. Aggregates shall be measured by weight to an accuracy of plus or minus 2 percent. The CONTRACTOR shall be responsible for insuring that adjustments are made in the mix due to surface moisture on the aggregate. Weight shall be based on a saturated, surface dry condition.

C. Water shall be measured by weight or volume to an accuracy of plus or minus 1 percent.

D. Admixtures shall be measured by weight or volume with an accuracy of plus or minus 3 percent.

CP-7 Mixing and Delivery

A. Concrete may be mixed at the job site, at a central point, or wholly or in part in truck mixers.

B. The following requirements shall apply to all mixers and the mixing process unless otherwise specified:

1. Mixer shall not be operated in excess of its nominal capacity as shown on the manufacturer's rating plate.

2. Mixer shall be operated at the drum speed recommended by the manufacturer.

3. When discharged, their contents shall be removed before materials are placed for the next batch.

4. Mixers shall ensure a uniform distribution of ingredients throughout the mass.

5. Upon cessation of mixing for more than 30 minutes, the drum shall be thoroughly cleaned.

C. Mixing at the jobsite shall be in accordance with the following:

1. The mixing time shall not be less than one minute for mixers having a capacity of one cubic yard or less with an increase of 15 seconds for each cubic yard, or portion thereof, of additional mixing capacity.

2. For mixers with a capacity in excess of 3 cubic yards, the minimum mixing time may be reduced to 1-1/2 minutes provided that the mixture is a homogeneous, uniform mass.

3. Other mixing times shall be subject to the approval of the ENGINEER.

4. Mixing time shall be measured from the moment all solid materials are placed in the mixer drum, provided that all water is added before one-fourth of the mixing time has elapsed. About 10 percent of the mixing water shall be added to the drum before the solid materials.

5. Stationary mixers shall be equipped with acceptable discharge locking devices which shall permit discharge only after the specified mixing time has elapsed.

D. Ready-mixed concrete may consist of central-mixed, shrink-mixed, or truck-mixed concrete.

E. Central-mixed concrete may be delivered in a truck agitator, a truck mixer operating at agitating speed, or a special non-agitating truck.

F. Shrink-mixed concrete shall be initially mixed in a stationary mixer a minimum of 30 seconds. Final mixing shall be done in truck mixers with concrete to be discharged before the drum or blades have exceeded 300 revolutions. In addition, truck mixing at mixing speed shall not exceed 100 drum or blade revolutions.

G. Truck-mixed concrete shall meet the following requirements:

1. Truck-mixed concrete shall be completely mixed in the truck with the mixing beginning within 30 minutes after loading.

2. Concrete shall be mixed for not less than 70 nor more than 150 revolutions at mixing speed. A maximum of 300 revolutions shall be allowed with revolutions in excess of 150 at agitating speed.

H. Special non-agitating trucks shall be subject to the approval of the ENGINEER. Use of this equipment shall require that discharge shall be completed within 30 minutes after introduction of the mixing water to the cement and aggregates.

I. In addition to the above requirements, the following requirements shall apply:

1. All concrete must be discharged from the mixer within 1-1/2 hours after the introduction of all water provided the air or concrete temperature does not exceed 70°F. When the temperature exceeds 70° F, a time limit of 1 hour shall be required.

2. Time limits for discharging shall be shortened by 15 minutes when Type IIIA cement is used.

3. The time limit for delivery by any method may be extended by a specified amount with the use of approved admixtures.

4. The ENGINEER may permit mixing and the adding of the cement and additives at the jobsite in truck mixers in order to meet the time limits.

CP-8 Cold Weather Concreting

A. The CONTRACTOR shall adhere to cold weather concreting practices in accordance with ACI 306R and the measures indicated in this section.

B. Cold weather concreting shall require that all snow, ice and other frozen material be removed from the site.

C. Concrete shall not be placed when the ambient air temperature is below 40°F unless authorized by the ENGINEER.

D. The CONTRACTOR shall place and maintain concrete at the following temperatures for a given section thickness:

1. <12 inches: 55°F

2. 12-36 inches: 50°F

3. 36-72 inches: 45°F

4. >72 inches: 40°F

E. Concrete shall be maintained at the appropriate temperature for least 72 hours after placement to allow for initial curing. Maintain concrete at at least 32°F for the remainder of the specified curing period.

F. The CONTRACTOR shall have adequate equipment and means available to heat concrete materials. The equipment used shall heat the mass uniformly to avoid hot spots.

G. When concreting is authorized at temperatures less than 40°F, the aggregates and water shall be heated to not less than 70°F and not more than 150°F.

H. Any variance to the limiting construction temperatures shall be subject to the ENGINEER's approval but shall not relieve the CONTRACTOR's responsibility for satisfactory results.

I. Reinforcement bars, forms, fillers, and other materials in contact with concrete shall not be less than 35°F at time of pouring. Preheat if temperature falls below 35°F.

CP-9 Hot Weather Concreting

A. The temperature at the time of placement during hot weather shall not exceed 90°F. Any variance to this temperature limit shall be subject to the ENGINEER's approval but shall not relieve the CONTRACTOR's responsibility for satisfactory results.

B. The CONTRACTOR may cool the aggregates by fogging, sprinkling, or other suitable means so long as there is no variation in the moisture content.

C. Crushed or flaked ice may be used as a portion of the mixing water on a pound for pound basis so long as all ice is melted before placement of concrete.

D. Water may be cooled by refrigeration.

E. Cooling of the forms and reinforcing steel shall be acceptable except that pools of water within the forms shall not be allowed.

F. Rate of evaporation from concrete shall not exceed 0.2 $lb/in^2/hr$ based on ACI 305R Table 2.1.5. CONTRACTOR shall apply fog spray, evaporation retardants, or other measures to stay below this rate.

CP-10 Preparation of Crushed Stone Base

A. The crushed stone base shall be constructed in accordance with Section GA - Graded Aggregate of this Specification.

B. The final depth, width and slope of the crushed stone base shall conform to the typical section(s) shown on the plans.

C. Final surface shall be constructed to within 0.025 foot tolerance of the planned elevation and shall be free of ruts and depressions.

D. The CONTRACTOR shall be required to mill the final surface of the crushed stone base to obtain the design finished subbase elevation. Trimming of subbase shall be done by equipment that is approved by the ENGINEER. The subbase shall be sprinkled with

water during such times and in such a manner as directed by the ENGINEER so that it shall be in a moistened condition when concrete is deposited.

CP-11 Forms

A. Forms shall meet the following requirements:

1. Forms shall be of metal with a base width not less than the height, except a 9 inch base width shall be permitted for 10 inch thick pavement. The height shall be equal to the edge thickness of the pavement.

2. Each form section shall be straight and free from bends and warps. No section shall show a variation greater than 1/8 inch in 10 feet from the true plane surface on the top, and 1/4 inch in 10 feet along the face of the form.

3. The method of connecting the forms shall ensure a tight, neat joint.

4. Special forms of wood or steel shall be permitted for curved form lines having a radius of 200 feet or less and must be approved for use by the ENGINEER.

5. Forms with battered top surfaces, and forms that are bent, twisted, or broken shall not be used.

B. Setting of forms shall meet the following requirements:

1. Pavement form shall be firmly in contact with the subbase for the whole length of the form. Any grade along the form line which is below the specified grade shall be filled with stone, as specified in Section GA - Graded Aggregate, in lifts of 1/2 inch or less. The use of shims or wedges under pavement forms shall not be permitted.

2. Forms shall be set sufficiently in advance of the point where concrete is being placed, but not less than 800 feet ahead of the mixer or in advance of placing the concrete.

3. After the forms have been set to the correct grade, the grade shall be thoroughly tamped, mechanically, or by hand, at both the inside and outside edges of the base of the forms.

4. Forms shall be staked into place with not less than 3 pins for each 10 foot section. A pin shall be placed at each side of every joint.

5. Form sections shall be tightly locked, free from play or movement in any direction.

6. The form shall not deviate from true line by more than 1/4 inch at any point.

7. No excessive settlement or springing of forms under the finishing machine shall be tolerated.

8. Forms shall be cleaned and oiled prior to the placing of concrete. Reuse of forms shall be allowed only if they are cleaned and oiled prior to reuse.

C. The removal of forms shall meet the following requirements:

1. Forms shall not be removed from freshly placed concrete until it has been set for at least 12 hours.

2. Forms shall be removed carefully so as to avoid damage to the pavement.

3. Honeycombed areas shall be considered to be defective work and shall be immediately repaired.

4. If the forms are removed prior to 72 hours after placing concrete, the sides of the pavement shall be cured by one of the methods specified in subsection CP-17 of this Section.

CP-12 Placing of Reinforcement

A. Reinforcement (tie bars, dowels and steel welded wire fabric) shall be placed as specified in this Section and as shown on the plans.

B. Reinforcement shall be inspected in place and approved by the ENGINEER before placement of the concrete.

CP-13 Placement of Concrete Pavement Using Forms

A. Concrete shall be deposited over the entire width of the sub-base between forms in such a manner as to prevent segregation and to require as little rehandling as practicable.

B. Unless paving mixers, truck agitators, or non-agitating hauling equipment are equipped with means for discharge of concrete without segregation of the materials, the concrete shall be unloaded into an approved spreading device and mechanically spread on the grade in such a manner as to prevent segregation of the materials.

C. Placing shall be continuous between transverse joints without the use of intermediate bulkheads.

D. Necessary hand spreading shall be done with shovels, not rakes.

E. Workmen shall not walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

F. Where concrete is to be placed adjoining a previously constructed lane of pavement, and mechanical equipment shall be operated upon the existing lane of pavement, that lane shall have attained the strength specified for the 14 day concrete. If only finishing equipment is operated on the edge of the existing lane, paving in adjoining lanes may be permitted after 3 days.

G. Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the hopper is well centered on the joint assembly.

H. Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by methods approved by the ENGINEER.

I. Reinforced concrete pavement shall be placed as follows:

1. Reinforced concrete pavement shall be placed in 2 layers.

2. The entire width of the bottom layer shall be struck-off to such length and depth that the sheet of wire fabric may be laid full length on the concrete in its final position without further manipulation.

3. The reinforcement shall be placed directly upon the concrete, and the top layer of the concrete placed, consolidated and finished.

4. Any portion of the bottom layer of concrete which has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the CONTRACTOR's expense.

J. Tie bars shall be supported in the proper position by chairs driven into the subgrade, or may be placed by approved mechanical methods prior to the consolidation of the concrete after it has been struck-off.

K. Final strike-off, consolidation and finishing shall be in accordance with subsection CP-15 of this Section.

L. The completed pavement may be opened to traffic, including construction traffic, when 7 days have elapsed.

CP-14 Placement of Concrete Pavement Using Slip Form Method

A. At the option of the CONTRACTOR, the pavement may be constructed by use of a slip form method.

B. The concrete shall be placed with an approved slip form paver or combination of pavers designed to spread, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finish is necessary to provide a dense and homogeneous pavement in conformance with the plans and this Specification.

C. The machine shall vibrate the concrete for the full width and depth of the strip of pavement being placed.

D. The concrete shall be held at a uniform consistency, having a slump of not more than 3 inches.

E. The slip form paver shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering and spreading concrete shall be coordinated as to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

F. The finish grade of the pavement shall be accurately controlled from a grade line pre-set parallel to the finish grade. Slip form paving equipment shall have controls that will trace the grade line and automatically adjust the grade of the screeds or extension meters.

CP-15 Final Strike-off, Consolidation and Finishing

A. The sequence of operations shall be strike-off and consolidation, floating and removal of laitance, straight-edging and final surface finishing.

B. Any addition of water to the surface of the concrete to assist in the finishing operations shall not be permitted. When conditions are such that unusually rapid drying is occurring, an atomized mist may be used to prevent the rapid evaporation of water from the concrete surface during the final finishing.

C. Consolidation and strike-off shall be accomplished by machine finishing as follows:

1. The concrete shall be distributed as soon as placed and shall be struck-off and screeded by an approved finishing machine, conforming to subsection CP-4 of this Section, so that when consolidated and finished, the surface of the pavement has the required elevation and cross section.

2. A sufficient and uniform amount of concrete shall be carried in front of the screed at all times to ensure the filling of all voids and depressions.

3. If the rate of placement exceeds the capacity of a single machine, additional machines shall be used.

4. The operations shall be controlled so that an excess of mortar and water is not worked to the top. Segregated particles of coarse aggregate which may have collected in front of the screed shall be thoroughly mixed by hand with the unfinished concrete already on the sub-base. Under no circumstances shall aggregate particles be carried forward by the finishing machine and pushed onto the sub-base in front of the machine.

5. Unless otherwise specified, full width vibration shall be performed. If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures and throughout the pavement, the CONTRACTOR shall furnish equipment and methods which will produce pavement conforming to these Specifications. Vibrators shall not come in contact with a joint assembly, the sub-base, or side form. In no case shall the vibrator be operated longer than 10 seconds in any one location.

6. Finishing at joints shall conform to the following:

    a. The concrete adjacent to joints shall be consolidated or firmly placed without voids or segregation against the joint, under and around all load transfer devices, joint assemblies and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated.

    b. The operation of the finishing machine over the joints shall not cause segregation of concrete and damage to or misalignment of joints.

7. Hand finishing shall not be permitted except under the following conditions:

    a. In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade.

    b. Areas of narrow widths or irregular dimensions, where operation of mechanical equipment is impractical, may be finished by hand.

    c. Concrete, as soon as placed, shall be struck off and screeded. A portable screed shall be used. If reinforcement is used, a second screed shall be provided for striking off the bottom layer of concrete.

    d. The surface screed shall be at least 2 feet longer than the maximum width of the slab to be struck off. It shall be sufficiently rigid to retain its shape under all working conditions, and constructed either of metal or of other suitable material shod with metal.

    e. Consolidation shall be attained by the use of suitable vibrator or other equipment.

    f. In operation the screed shall be moved forward on the forms in the direction the work is progressing, using a combined longitudinal and transverse shearing motion, so manipulated that neither end is raised from the side forms during the striking process. This shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

D. After the concrete has been struck off and consolidated, it shall be further smoothed and trued by means of a longitudinal float, using one of the following methods:

1. Hand method meeting the following requirements:

    a. The hand-operated longitudinal float shall be at least 12 feet long and 6 inches wide, properly stiffened to prevent flexibility and warping.

    b. The longitudinal float, operated from foot bridges spanning but not touching the concrete, shall be worked with a sawing motion while held in a floating position parallel to the centerline of the pavement, and passing gradually from one side of the pavement to the other.

c. Movement ahead along the centerline of the pavement shall be in successive advances not more than one-half the length of the float.

d. Excess water and soupy material shall be wasted over the sides on each pass.

2. Mechanical method meeting the following requirements:

a. The mechanical longitudinal float shall be of a design approved by the ENGINEER, and shall be in good working condition.

b. The float shall be accurately adjusted to the required crown, if any, and coordinated with the adjustments of the transverse finishing machine so that a small amount of mortar is carried ahead of the float at all times.

c. The float shall pass over each area of pavement at least 2 times, but excessive operation over a given area shall not be permitted.

d. Excess water and soupy material shall be wasted over the sides on each pass.

e. As an alternative to the mechanical method, the CONTRACTOR may use a machine composed of a cutting and smoothing float, or floats, suspended from and guided by a rigid frame. The frame shall be carried by 4 or more visible wheels riding on and constantly in contact with the side forms, or track line of a slip form paver.

3. If necessary, following one of the preceding methods of floating, long-handled floats having blades at least 5 feet long and 6 inches wide may be used to smooth and fill in open-textured areas in the pavement as follows:

a. Long-handled floats shall not be used in lieu of, or to supplement, one of the preceding methods of floating.

b. When strike-off and consolidation are done by the hand method and the crown of the pavement will not permit the use of the longitudinal float, the surface shall be floated transversely by means of the long-handled float. Care shall be taken not to work the crown out of the pavement during the operation.

c. After floating, excess water and laitance shall be removed from the surface of the pavement by a straightedge 10 feet or more in length. Successive drags shall be lapped one-half the length of the blade.

E. Immediately following the machine floating and while the concrete is still plastic, the CONTRACTOR shall test the pavement surface for trueness by means of a straightedge 10 feet in length as follows:

1. Straightedging shall be done by holding the straightedge in contact with the concrete surface, parallel to the pavement centerline, and drawing the straightedge lightly across the surface.

2. Advance along the pavement shall be in successive stages of not more than one-half the length of the straightedge.

3. All variations shall be eliminated by filling depressions with freshly mixed concrete or striking off projections and the areas so corrected shall be consolidated and refinished by means of a long handled float.

4. The surface shall again be checked by the CONTRACTOR by means of the straightedge and any irregularities eliminated.

5. Final surface variation shall not exceed 1/8 inch.

6. Any concrete surface which does not meet the 1/8 inch surface tolerance and has set up can be corrected by grinding. Concrete grinder shall be approved by the ENGINEER. If depressions cannot be corrected by grinding, the concrete shall be replaced by the CONTRACTOR at his expense.

F. After the pavement surface has been prepared as described above, a final finish shall be attained by dragging the surface with seamless strips of damp burlap. Drags that cannot be cleaned of encrusted mortar shall be discarded.

CP-16 Testing

A. Slump tests shall be performed by the CONTRACTOR at the direction of the ENGINEER and shall meet the following requirements:

1. In general, the tests shall be performed at the start of operations each day and whenever the appearance of the concrete indicates a change in the mix.

2. The tests shall be performed in accordance with AASHTO T 119 or T 183.

3. The slump shall not exceed 4 inches.

B. Concrete strength tests shall meet the following requirements:

1. During the pouring of the ready-mix concrete, the CONTRACTOR shall collect and mold 4 concrete cylinders from each pour.

2. The CONTRACTOR shall be responsible for keeping a record of the test cylinder, batch number, pour location and date.

3. Samples shall be made and cured in the lab according to AASHTO T 126.

4. Samples shall be tested in accordance with AASHTO T 22.

5. The strength level of the concrete shall be considered satisfactory if no individual strength test result falls below the specified strength by more than 500 psi and the average of any 3 consecutive tests is equal to or greater than the specified strength.

CP-17 Curing

A. Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured in accordance with one of the methods described herein.

B. If the CONTRACTOR fails to provide sufficient curing materials, the ENGINEER may order the immediate suspension of concreting operations.

C. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

D. When concrete is being placed and the air temperature may be expected to drop below 35°F, a sufficient supply of straw, hay, or other suitable blanketing material shall be provided to protect the concrete. The CONTRACTOR shall be responsible for the quality and strength of the concrete placed during cold weather, and all concrete injured by frost action shall be removed and replaced at the CONTRACTOR's expense.

E. Curing materials shall conform to subsection CP-3 of this Section.

F. Polyethylene coated burlap and white polyethylene sheeting shall be permitted as a curing application only on areas where intimate contact with the concrete surface can be obtained and maintained.

G. Burlap curing shall meet the following requirements:

1. The surface of the pavement shall be entirely covered with the mats.

2. Mats shall be of such length that they extend at least twice the thickness of the pavement beyond the edges of the slab.

3. The mat shall be placed so that the entire surface and both edges of the slab are completely covered.

4. Before placing, the mats shall be thoroughly saturated with water.

5. The mats shall be weighted down so as to remain in intimate contact with the surface covered and shall be maintained fully wetted and in position for 72 hours after the concrete has been placed, unless otherwise specified.

H. Straw curing shall meet the following requirements:

1. When this type of curing is used, the pavement shall be cured initially with burlap mats, as specified above, until after final set of the concrete or, in any case, for 12 hours after placing the concrete.

2. As soon as the mats are removed, the surface and sides of the pavement shall be thoroughly wetted and covered with at least 8 inches of straw or hay, thickness to be measured after wetting.

3. The straw or hay shall be kept thoroughly saturated with water for 72 hours after placing the concrete.

4. If the straw or hay becomes displaced during the curing period, it shall be replaced to the original depth and saturated.

5. Upon removal, the covering shall be properly disposed of. Removed straw or hay may be used for mulching in accordance with Section SM - Seeding and Mulching of these Specifications.

I. Curing by the use of a liquid membrane forming compound (white pigmented) shall meet the following requirements:

1. After the concrete has been finished, and immediately after the surface water has disappeared, the entire surface of the pavement shall be cured by mechanically applying thereon a uniform coating of the curing compound.

2. If conditions arise which prevent immediate application, the surface shall be kept wet with a fine spray of water during checking of the surface, sawing of joints if required, and until the application of the compound is started.

3. Joints shall be protected by an approved method so that the compound will not enter the joint.

4. The material shall be applied in 1 or 2 applications as directed by the manufacturer. When applied in 2 applications, the second shall follow the first within 30 minutes.

5. The compound shall be applied in a continuous uniform film by means of a power operated pressure spraying or distributing device at the rate specified by the manufacturer, but no less than one gallon per 150 square feet of surface.

6. The equipment for applying the compound shall provide for adequate agitation of the compound during application and shall be approved by the ENGINEER before work is started.

7. If the compound is too thick for satisfactory application during cold weather, the material may be warmed in a water bath at a temperature not over 100°F.

8. Thinning with solvents shall not be permitted.

9. Hand spraying of areas with irregular widths and shapes and surfaces exposed by the removal of forms shall be allowed.

10. Should the method of applying the compound produce a non-uniform film, its use shall be discontinued and the curing done by another method specified herein.

11. If rain should fall on the newly coated pavement before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, a new coat of material shall be applied to the affected areas equal in curing rate to that specified for the original coat.

12. The treated surface shall be protected from injury until the expiration of the curing period, 72 hours after placement of the concrete unless otherwise directed by the ENGINEER.

13. All vehicles and pedestrian traffic shall be considered injurious to the film of applied compound and shall be prohibited. However, a minimum of walking may be permitted on the dried film as necessary to carry on the work properly, provided any damage to the film is immediately repaired by the application of a second coat of compound.

14. If there should be a breakdown of the spraying equipment, protection of the uncoated pavement shall be provided.

15. Upon removal of the side forms, the sides of the exposed slabs shall be protected immediately with a treatment equal to that provided for the surface.

J. Curing using white polyethylene sheeting shall meet the following requirements:

1. The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting.

2. Sheets shall be overlapped a minimum of 18 inches.

3. The covering shall be weighted down so as to remain in intimate contact with the surface covered.

4. The covering shall extend at least twice the thickness of the pavement beyond the edges of the slab.

5. The covering shall be maintained in place at least 72 hours after the concrete is placed, unless otherwise specified by the ENGINEER.

K. Curing using waterproof paper shall meet the following requirements:

1. The top surface and sides of the pavement shall be entirely covered with waterproof paper.

2. Sheets shall be overlapped a minimum of 18 inches.

3. The covering shall be weighted down so as to remain in intimate contact with the surface covered.

4. Each sheet as laid shall extend at least twice the thickness of the pavement beyond the edges of the slab. Paper not manufactured in sizes providing this width shall be securely sewed or cemented together, the joints being securely sealed in such a manner that they do not open up during curing.

5. The surface shall be thoroughly wetted before placing the paper.

6. The covering shall be maintained in place at least 72 hours after the concrete is placed, unless otherwise specified by the ENGINEER.

CP-18 Joints

A. All joints shall be constructed in accordance with the type and dimensions and at the locations as shown on the plans or as directed by the ENGINEER.

B. Transverse construction joints shall be constructed as specified at the end of each day's work and whenever pouring is suspended for a period of 30 minutes. No construction joint shall be placed closer than 10 feet to another joint.

C. Unless otherwise directed by the ENGINEER, the CONTRACTOR may choose the method of joint construction for a particular type of joint that best suits the work.

D. All joints shall be constructed normal to the concrete surface.

E. Joint materials shall conform to subsection CP-3 of this Section.

F. Longitudinal joints (between adjacent slabs) shall be constructed by one of the following methods:

   1. When adjacent slabs are constructed separately the following shall apply:

      a. Dowels shall be placed perpendicular to the longitudinal joint prior to placing the concrete.

      b. Tie bars may be bent in order to place forms of the first slab and then straightened into final position before the concrete of the adjacent slab is placed.

   2. When adjacent slabs are constructed simultaneously the following shall apply:

      a. Dowels shall be placed perpendicular to the longitudinal joint prior to placing the concrete.

      b. The joint shall be formed by sawing a continuous slot with an approved concrete saw.

c. Sawing shall begin as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling and shall be done within 24 hours after placing the concrete.

d. All joints shall be sawed before uncontrolled shrinkage cracking takes place.

e. The slot shall be cut to a depth as shown on the plans.

f. Sawed areas shall be thoroughly cleaned and filled with a sealer.

g. A removable insert may be used in lieu of a saw cut.

h. An alternate method to using a slot and sealer may consist of using a permanent plastic insert.

G. If a crack occurs during the curing period between sawed joints, the pavement shall be removed at the CONTRACTOR's expense from a saw cut at the crack to the nearest joint with a minimum replacement of 5 feet.

H. Transverse expansion joints shall meet the following requirements:

1. Joints shall consist of a dowel and a metal sleeve or tube assembly constructed with the dowels placed parallel to the slab centerline as shown on the plans.

2. As an alternate, a premolded joint filler, one piece and continuous from form to form and shaped to the cross section of the concrete, may be used. The filler shall be depressed 1/2 inch below the surface of the pavement.

3. Expansion joints that are placed around protruding objects such as curbs or manholes shall consist of a minimum 1/2 inch wide premolded joint filler or other suitable material.

I. Transverse contraction joints shall meet the following requirements:

1. Joints shall consist of planes of weakness created by sawing grooves in the surface of the pavement as shown on the plans.

2. Sawing shall begin as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling and shall be done within 24 hours of placing the concrete.

3. All joints shall be sawed before uncontrolled shrinking cracks begin development.

4. A removable insert may be used in lieu of a saw cut.

J. All joints shall be sealed in accordance with the following requirements:

1. Joint material shall meet the requirements of subsection CP-3 of this Section.

2. Joints shall be sealed by one of the two following methods:

a. A poured joint sealer shall consist of a hot or cold poured material, placed by hand or machine, capable of effectively sealing joints through repeated cycles of contraction and expansion. Poured joint sealer shall not be applied when the air temperature in the shade is less than 50°F.

b. A preformed elastomeric seal (backer rod type) shall be installed with the use of an approved lubricant adhesive and in a compressed condition with the top of the seal 1/4 inch below the surface. Diaphragm type seals are also acceptable. Use of these types of seals shall be in accordance with the manufacturer's recommendations.

3. All joints shall be sealed before pavement is opened to traffic, and as soon after completion of a minimum curing period of 72 hours.

4. All joints shall be thoroughly cleaned and dry before applying joint sealer.

5. The sealing material shall be installed in such a way as to fill the joint opening completely, and uniformly from the bottom to the top.

6. Any excess joint material shall be removed from the pavement surface.

CP-19 Faulty Concrete

A. If early tests of concrete indicate that the required 28 day strength may not be reached, the CONTRACTOR shall provide additional curing as directed by the ENGINEER.

B. It the concrete is faulty on account of low strength as indicated by test or faulty in other respects, the CONTRACTOR shall provide cores from the poured concrete if requested or shall remove and replace the faulty concrete, if so directed by the ENGINEER.

C. All costs incidental to faulty concrete, including any additional curing required shall be borne by the CONTRACTOR.

CP-20 Measurement and Payment

A. Measurement

1. Measurement of concrete pavement placed shall be number of finished square yards placed by type and thickness, as measured by the ENGINEER or as otherwise shown on the Plans or bid sheet..

2. Dolly pads, craneways, or other linear features shall be measured per linear foot installed by type.

3. All linear and surface area measurements shall be based on planimetric measurements (two-dimensional planar surface projection). No allowance shall be made for pavement cross-slopes, crowns, or other vertical features.

B. Payment

1. Payment for concrete pavement will be made at the Contract unit bid price for concrete pavement for the type and thickness of pavement shown on the plans, which price shall constitute full compensation for all materials, including reinforcing steel, transverse and longitudinal joints, expansion joint filler, silicone sealant, dowels or load transfer devices, curing materials and other material incidental to the work; preparation of the subbase; placing, finishing and curing; and all labor, equipment, tools, testing, supplies and incidentals necessary to complete the work.

2. Payment for craneways, dolly pads, and other linear features shall be made at the Contract unit price per linear foot installed by type. The price shall constitute full compensation for all materials, including reinforcing steel, transverse and longitudinal joints, expansion joint filler, silicone sealant, dowels or load transfer devices, curing materials and other material incidental to the work; preparation of the subbase; placing, finishing and curing; and all labor, equipment, tools, testing, supplies and incidentals necessary to complete the work.

3. Costs of preliminary strength testing for an alternate mix design will be borne by the CONTRACTOR. Costs for final strength testing, slump tests, and air tests will be included in the Contact unit bid price for concrete pavement. Any other strength testing performed for the benefit of the CONTRACTOR (such as determining an earlier time for form removal) will be paid for by the CONTRACTOR.

4. No separate payment shall be made for the following:

    a. Hot or cold weather paving precautions.

    b. Replacement of faulty concrete pavement caused by weather conditions, deficiencies in structural strength, and/or CONTRACTOR's negligence.

    c. CONTRACTOR substitution of a higher strength concrete.

    d. Use of additional cement or additives required for air-entraining concrete.

END OF SECTION

Section GA – Graded Aggregate

GA-1 Description

The Work shall consist of furnishing and installing graded aggregate as shown on the plans or as directed by the ENGINEER.

GA-2 General Conditions

A. Clean filter aggregate for use as backfill for trench drains, or drainage material for underdrain systems (2 sizes).

   1. A1 – Coarse filter aggregate

   2. A2 – Fine filter aggregate

B. Dense graded aggregate for use as roadway/pavement subbase, railroad subballast, structural bedding, or culvert bedding.

C. Large graded aggregate for use as erosion protection, channel lining, and armor stone (3 sizes).

   1. C1 – 3 inch erosion stone.

   2. C2 – Small riprap, sized 6 inches to 18 inches, up to 200 pounds.

   3. C23 – Medium riprap sized 12 inches to 24 inches, up to 800 pounds

   4. C3 – Large riprap, sized 18 inches to 36 inches, up to 4000 pounds.

   5. C4 – Surge stone (shot rock)

D. Railroad ballast for use in track structure (2 sizes) shall conform to the requirements of Section BA - Ballast of the Specifications.

E. The CONTRACTOR shall furnish a certification of compliance stating that the material meets or exceeds the requirements of the specification.

F. All graded aggregate shall be approved by the ENGINEER prior to installation.

G. Only those aggregate sources which are fully certified to produce material for the local State Department of Transportation are to be utilized, unless prior approval is obtained from the COMPANY.

H. Graded aggregates subject to on site stockpiling prior to placement shall be reblended as directed by the ENGINEER to ensure compliance with the original gradation specified.

I. Crushing excavated rock on-site for use on the project must be approved by the ENGINEER.

GA-3 Material

A. Category A material (clean filter aggregate) shall meet the following specification:

1. Type A1 - Coarse filter aggregate shall comply with either AASHTO gradations No. 67, No. 7, or No. 78, as shown in Table 1 below.

2. Type A2 - Fine filter aggregate shall comply with AASHTO gradation No. 10, as shown in Table 1 below, modified to have no more than 5 percent passing No. 200 Sieve. Permeability will be at least 0.05 cm/sec as measured by AASHTO T 215.

3. Material will be produced from sound rock or naturally occurring deposits, and will be free from organics and deleterious material as defined by AASHTO T 112.

4. Use of material with an LA abrasion greater than 30%, per AASHTO C-131, must be approved by the ENGINEER.

NS Type:	AASHTO Gradation:	Percent Passing Standard Sieve Size by Weight								
		1"	3/4"	1/2"	3/8"	#4	#8	#16	#100	#200
A1	#67	100	90-100	-	20-55	0-10	0-5	-	-	-
	#7	-	100	90-100	40-70	0-15	0-5	-	-	-
	#78	-	100	90-100	40-75	5-25	0-10	0-5	-	-
A2	#10	-	-	-	100	85-100	-	-	10-30	(0-5)*

** Company specification requirement.*

Table 1: Type A Graded Aggregate Gradations

B. Category B material shall meet the following specification:

1. Dense graded aggregate shall comply with the NS gradation as shown in Table 2 below. This gradation may be modified at the discretion of the ENGINEER to accommodate locally produced dense graded aggregate (aggregate base) that complies with local State Department of Transportation specifications or as shown on plans.

2. Material shall be produced from sound rock or naturally occurring deposits, and shall be free from organics and deleterious material as defined by AASHTO T 112. The material must not have a Liquid Limit (LL) in excess of 25 (AASHTO T 89), or a Plasticity Index (PI) in excess of 6 (AASHTO T 90).

3. Original source of the dense graded aggregate shall have a Percentage of Wear (LA Abrasion) no greater than 50 percent (AASHTO T 96).

NS Type:	Percent Passing Standard Sieve Size by Weight					
	2"	1"	3/8"	#10	#40	#200
B	100	90-100	50-84	26-50	12-30	5-12

Table 2: Type B Graded Aggregate Gradations

4. Use of Material produced from Recycled Concrete must be authorized by the ENGINEER and meet the following specifications:

   a. Reclaimed concrete aggregate base shall not contain plastic soils; that portion finer than a No. 40 sieve shall be non-plastic.

   b. Reclaimed concrete aggregate base shall be free of all materials that fall under the category of solid waste or hazardous materials as defined by state or local jurisdiction. Reclaimed concrete aggregate base shall meet all Department of Environmental Protection permit requirements which pertain to construction, demolition and recycling of these materials. Reclaimed concrete aggregate base shall be substantially free from Reclaimed concrete aggregate base shall be asbestos free.

   c. Recycled Concrete shall include no bituminous concrete, bricks, wood or other organic substances, or plaster/gypsum board.

   d. The following limits shall not be exceeded:

      i. Heavy Metals (except Lead) 0.1% by weight

      ii. Lead 5 parts per million

      iii. Reinforcing Steel and Welded Wire Fabric 0.1% by weight

   e. Gradation of Recycled Concrete type B material shall not differ from materials from original sources.

   f. Acceptance for use of Recycled Concrete category B material may, at the discretion of the ENGINEER, be subject to a field test of a short section of material, placed and compacted to plan depth and width, proof rolled or compaction tested.

   g. Recycled Concrete category B material is not to be used under reinforced concrete pavement or structure construction north of North Carolina and Tennessee.

5. Recycled asphalt is not allowed for use as Type B material.

C. Category C material shall meet the following specification:

1. Type C1 - 3 inch erosion stone shall comply with AASHTO gradation No. 1, as shown in Table 3 below.

	Percent Passing Standard Sieve Size by Weight							
NS Type:	4"	3 1/2"	3"	2 1/2"	2"	1 1/2"	1"	3/4"
C1	100	90-100	-	25-60	-	0-15	-	0-5

Table 3: Type C1 Graded Aggregate Gradations

2. Type C2 - Small riprap shall consist of reasonably well graded pieces sized up to 2 cubic feet, with not more than 10 percent passing a 5 inch square screen. Weight will typically be between 10 and 200 pounds.

3. Type C23 – Medium riprap shall consist of reasonably well graded pieces sized up to 7 cubic feet, with not more than 10% passing a 12" square screen. Weight will typically be between 100 and 800 pounds.

4. Type C3 - Large riprap shall consist of reasonably well graded pieces sized up to 1 cubic yard, with not more than 10 percent passing 12 inch square screen. Weight will typically be between 200 and 4000 pounds.

5. Type C4 - Surge Stone (shot rock) shall consist of quarry production material that is unsorted and may contain variable sized pieces and rock fines. The ENGINEER will determine if the size range of material from a particular source is appropriate for usage on the individual project.

6. Material shall be produced from sound durable rock with a specific gravity of at least 2.50. Percentage of Wear (L.A. Abrasion) not greater than 50 percent (AASHTO T 96). The material shall be free of cracks, soft seams, or other structural defects. The pieces shall be roughly angular and shall be reasonably free from thin, flat or elongated pieces. Types C1, C2, and C3 will be relatively free of dust and fines.

7. As shown on project plans or as directed by the ENGINEER, rock excavated on site as part of the project may be utilized provided that it meets the requirements of this specification section.

8. Type C stone made from recycled concrete shall not be used until evaluated and accepted for use by the ENGINEER. It shall be free of solid wastes, hazardous substances, steel reinforcing (up to 0.1% allowed), asbestos, deleterious materials, and comply with local environmental regulations.

GA-4 Delivery

A. Unless otherwise specified by project contract, the CONTRACTOR shall be responsible for furnishing graded aggregate.

B. If graded aggregate is specified by project contract to be furnished by the COMPANY, it shall be delivered to the nearest available track (as determined by the COMPANY) in COMPANY owned gondola or hopper cars. The CONTRACTOR shall be responsible for prompt unloading of the cars and for the transport of the material to the job site for installation or stockpiling.

C. The ENGINEER, or person(s) designated by the ENGINEER, shall collect quarry tickets for each load of graded aggregate used at the job site.

D. The ENGINEER may refuse acceptance, at no cost to the COMPANY, if it is determined by testing that the material being supplied is unsuitable or visibly not within specifications.

GA-5 Installation

A. All categories of graded aggregate shall be placed in accordance to project plans, using standard construction practices and equipment. Changes or substitutions must be approved in advance of installation by the ENGINEER.

B. Category A materials shall be installed as follows:

1. Filter materials shall be placed and fully compacted in lifts not to exceed 6 inches in thickness following compaction.

2. When used in combination, care shall be taken not to mix types A1 and A2 during installation.

3. Filter materials contaminated by native soils during installation shall be removed. Soil infiltration of the filter materials by the overlaying soil or subgrade course shall not be considered contamination.

C. Category B material shall be installed as follows:

1. Material shall be placed and fully compacted in lifts not to exceed 6 inches in thickness following compaction.

2. Compaction shall be 100 percent of Standard Proctor based on the compaction test methods of AASHTO T 180. The ENGINEER shall, at the COMPANY's expense, conduct field density tests to verify compaction.

3. Moisture content shall be controlled as necessary to obtain specified densities. Water shall be added when in the opinion of the ENGINEER, added moisture is necessary to obtain desired density. When the material is too wet to obtain desired density, the material shall be worked by discing, harrowing, or other means to dry the material to a workable moisture content. Tolerance shall be plus or minus 2 percent from optimum moisture.

4. Delivery of crushed stone furnished by the CONTRACTOR may be refused at no cost to the COMPANY, if, in the opinion of the ENGINEER, the moisture content is excessive. If pugmill is used, the ENGINEER shall be furnished the results of moisture content tests performed at the quarry to determine the average moisture content. Weight shall be deducted from the quarry tickets for any moisture content over 6 percent.

5. Finished dense graded aggregate layer shall conform to the depth, width, and slope specified in the typical section(s) shown on the plans. Construction tolerances for the final surface of the dense graded aggregate layer shall be plus or minus 0.025 foot of planned elevation, unless otherwise shown on the plans, and shall be free of ruts and depressions. The CONTRACTOR shall be required to mill the final surface if deemed necessary by the ENGINEER to obtain specified section.

6. Damage to completed dense graded aggregate layer caused by the CONTRACTOR during subsequent operations shall be repaired by the CONTRACTOR at his expense prior to acceptance of work by the COMPANY. This shall include, but is not limited to, rutting, disintegrating stone shoulders, intermixing of foreign materials, or disturbance of finished surface layer to the extent that the material fails to achieve specified density.

D. Category C materials shall be installed as follows:

1. Prior to placement, subgrade or existing ground surface shall be excavated or regraded to conform to slopes and elevations specified in the plans. Any existing washes, ruts, or voids shall be filled and compacted to provide a uniform placement surface.

2. On slopes the material shall be placed in horizontal layers, roughly perpendicular to the slope. Category C materials shall not be placed on slopes steeper than their natural angle of repose.

3. Material shall be placed so that the random sized pieces are evenly distributed and "pockets" of excessively small or large material are avoided. The ENGINEER shall require redistribution of material if necessary.

4. Material layer thickness shall be uniform, and follow the plan lines as closely as possible. Thickness tolerances will be plus or minus 3 inches. This may be altered at the discretion of the ENGINEER to account for material size variations.

5. If placement of an engineering fabric beneath material is specified on the plans, it shall be installed in compliance with Section EF - Engineering Fabrics of these Specifications. Placement of material on fabric shall be done in a manner that shall not damage or destroy the fabric. The CONTRACTOR shall be responsible for repairs to the fabric if it is damaged.

GA-6 Measurement & Payment

A. Measurement

1. Measurement of quantities for all categories of graded aggregate furnished by the CONTRACTOR shall be by the number of tons as determined from the total of weigh slips for each vehicle load weighed upon an approved standard scale or from digital print-out slips from an automatic batching plant. Weigh slips shall be collected by the ENGINEER or his representative.

2. Measurement of quantities for all categories of graded aggregate furnished by the COMPANY shall be by the number of tons as determined from the total weigh bills for each car load or the billing invoice from the quarry.

B. Payment

1. Payment for all categories of graded aggregate furnished by the CONTRACTOR will be made at the contract unit bid price per ton for each category of graded aggregate placed, which price shall include all necessary material, labor and equipment required to furnish, transport and place the material.

2. Payment for all categories of graded aggregate furnished by the COMPANY will be made at the Contract unit bid price per ton for each category of graded aggregate placed, which price shall include all necessary material, labor and equipment required to place the material.

3. No separate payment will be made for the following:

   a. Placement of stone taken from excavation.

   b. Any excavation work required to place riprap at the proper elevation or to dress and shape an existing embankment for placing riprap. The cost of the work shall be included in the Contract unit bid price of furnishing and placing riprap.

END OF SECTION

Section RCC – Roller Compacted Concrete

RCC-1 Description

This specification outlines the requirements for production and construction of Roller Compacted Concrete (RCC) pavement for Company facilities. In addition, the requirements as stated in Section CP – Concrete Pavement, Sub-Sections CP-1, CP-2, CP-3, CP-8, CP-9, CP-10, CP-15, CP-17, CP-18, CP-19 and CP-20 of the Norfolk Southern Standard Specifications for Materials and Construction shall be met where applicable.

RCC-2 Submittals

A. The CONTRACTOR submitting a bid shall also include, as part of the bid, the following for review by the COMPANY:

1. Completed Project List – The proposed CONTRACTOR must provide evidence of the successful installation of RCC pavement on three prior projects of comparable size and application. The project listing shall include a brief description for each project as well as the final contract amount, the owner's name and contact information and the designing engineer's name and contact information.

2. Proposed Installation Equipment – The proposed contractor shall supply a list of the proposed installation equipment including mixing plant, paving equipment, and compaction equipment. The make, model, and equipment specification sheet for each piece of equipment shall be included.

3. Project Personnel – The proposed contractor shall submit resumes and references for the proposed RCC Project Manager and Project Superintendent. All are expected to have experience with a similar level of responsibility on at least 3 similar projects. Should the proposed contractor become the successful CONTRACTOR, the personnel proposed in this submission shall be assigned to this project. If for some reason the proposed personnel are not available for this project, replacement personnel shall be subject to qualification by the Company.

B. The CONTRACTOR shall submit the following to the ENGINEER at least 30 days before the start of any production of RCC Pavement:

1. Construction schedule for all RCC related operations.

2. Paving procedures describing direction of paving operations, paving widths, planned longitudinal and transverse cold joints, and curing methods and patterns. CONTRACTOR shall include a description of dual lift construction procedures and methods, including a description of additional equipment that may be used such as additional pavers and material transfer devices.

3. Description of precautions to be taken in the event of cold weather paving (<40°F) or hot weather paving (high temperatures and/or windy conditions). No additional payments will be considered for these precautions.

4. Certification for aggregate source, quality and sizing as required by this specification.

5. Certification for portland cement and supplementary cementitious materials as required by this specification.

6. Layout of plant location showing mixing plant, cement and aggregate storage, and water supply.

7. Mix design as outlined in Section RCC-4.

8. Test strip Plan and Procedure.

RCC-3 Material

A. All materials to be used for RCC pavement construction shall be acquired from documented sources approved by the ENGINEER.

B. Cement shall be Portland Cement Type I or Type I/II and shall conform to standard specification ASTM C 150 (latest edition).

C. Fly Ash shall conform to ASTM C 618 Class F.

D. Slag shall conform to ASTM C 989.

E. Silica Fume shall conform to ASTM C 1240.

F. Fine and course aggregates shall meet the requirements of section CP – Concrete Pavement Sub-Section CP-3, Paragraph D. The aggregates shall be well graded to conform to the following composite gradation:

Sieve Size	% Passing
1"	100
3/4"	85 - 100
1/2"	70 - 95
3/8"	60 - 85
#4	40 - 70
#16	15 - 40
#100	5 - 20
#200	0 - 8

G. Water shall be clean, potable, and free from oil, acid, and strong alkalis or organic materials.

H. Aggregate storage and handling:

1. Aggregate shall be stored at the site of the mixing plant, avoiding breakage, segregation or contamination by foreign materials. Each size of aggregate from each source shall be stored separately in free-draining stockpiles. Unless approved by the ENGINEER, at least 50% (fifty percent) of the aggregate required for the project/phase shall be maintained at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time RCC is being placed.

2. Aggregate shall be handled preventing segregation or degradation. Vehicles used for stockpiling or moving aggregate shall be kept clean of foreign materials.

RCC-4 Mix Design

A. The CONTRACTOR shall develop an RCC mixture proportioned in accordance with this specification and procedures discussed in ACI 325.10R-95 "State-of-the-Art Report on Roller-Compacted Concrete Pavements" sections 4.2 and 4.3. Once the mix has been designed, certified test data shall be submitted to and approved by the ENGINEER from a recognized testing laboratory that shows the proposed mix design will meet the requirements either as specified in the plans or the following:

1. Compressive Strength, Cylinders: 5,500 psi @ 28 days

2. Flexural Strength, Beams: 650 psi @ 28 days

3. Splitting Tensile Strength, Cores: 400 psi @ 14 days

4. Modulus of Elasticity: 4,000,000 psi

B. The minimum cementitious Material shall be 500 pounds per C.Y. Use of fly ash is not recommended to be used as part of the cementitious material. If Class F fly ash is approved as a replacement material, it shall not exceed 20% by weight.

C. Fly ash may only be used between April 1 and November 1 unless otherwise authorized by the ENGINEER.

RCC-5 Equipment

A. Mixing plants shall be of a design that can produce an RCC pavement mixture of the proportions defined in the approved mix design and within the specified tolerances in ASTM C 94 and ASTM C-685. The plant may be a Rotary Central-Mix Drum or a Stationary Continuous-Mixing Twin-Shaft Pugmill mixer. The plant shall have a minimum manufacturer's rated capacity of 200 CY per hour. The mixing plant shall be located to allow for no more than 30 minutes from end of mixing to RCC placement.

B. A pugmill plant shall be capable of batch or continuous mixing, equipped with synchronized metering devices and feeders to maintain the correct proportions of aggregate, cement, mineral admixture and water. For continuous operating pugmills, a

surge hopper attached to the end of the final discharge belt shall be provided to temporarily hold the RCC discharge to allow the plant to operate continuously.

C. A rotary central-mix drum batch mixer shall be capable of producing a homogeneous mixture, uniform in color and having all coarse aggregate coated with cementitious paste. The mixer shall be equipped with batching equipment that will measure the amounts of cement, mineral admixture and aggregate by direct weighing equipment and can be readily adjustable to compensate for moisture content of the aggregate, vibrators on the bulk cement and mineral weigh hoppers, measuring equipment capable of measuring the amount of water for each batch of RCC by weight or volume and a timing device for the drum mixers.

D. A high-density, asphalt-type paver modified or equipped with either dual tamping bars and vibrating screed or a single tamping bar and dual pressure bars, capable of laying down the RCC mix to at least 90% of the required density. The paver shall be of suitable weight and stability to spread and finish the concrete without segregation to the required thickness, smoothness, surface texture, cross-section, and grade. At the discretion of the ENGINEER, optional pavers may be considered acceptable if, by means of the Test Strip specified in RC-12, the CONTRACTOR can prove all requirements of this specification can be consistently achieved without detriment to the final product.

E. Pneumatic rollers, if used, shall be self-propelled, with overlapping tire positions capable of providing full compaction in a single pass. Static weight shall be no less than 10 tons, or more than 20 tons. Tire configuration shall be five (5) front and six (6) rear. Maximum speed of the roller shall be restricted to 1.5 mph.

F. Vibratory rollers shall be self-propelled, double drum, steel wheel vibratory rollers having a static weight of at least 10 tons and a dynamic force at least twice the static force. Each roller drum shall be equipped with a properly operating steel scraper. The rollers shall transmit a dynamic impact to the surface through smooth steel drums by means of revolving weights, eccentric shafts or other equivalent methods. The roller drum shall be between 4 and 5-1/2 foot in diameter and 5-1/2 to 8 feet in width. Maximum speed of the roller shall be restricted to 1.5 mph.

G. Finish rollers shall be self-propelled, double drum, steel wheel rollers having a static weight of between 3 and 10 tons. Each drum shall be equipped with a properly operating steel scraper. A single drum vibratory roller with a vulcanized rubber coating may be utilized for finish rolling, at the approval of the ENGINEER.

H. To cut vertical joints in fresh RCC pavement, equipment such as a wheel cutter or other approved equipment capable of cutting vertically, the full depth of the layer, shall be used. If the CONTRACTOR waits until the RCC hardens to make vertical cuts, concrete sawing equipment shall be used to make the vertical cuts.

RCC-6 Placing RCC

A. RCC shall not be placed on any surface containing frost or frozen material. RCC shall only be placed when the ambient temperature is a minimum of 35°F and rising. When the ambient temperature is expected to fall below 35° F, the CONTRACTOR must follow the procedures set forth in Sub-Section CP-8.

B. During periods of hot weather or windy conditions, special precautions shall be taken to minimize moisture loss due to evaporation. Precautions may include cooling of aggregate stockpiles by the use of a water spray, protective covers on dump trucks, temporary windbreaks to reduce wind velocity, cooling of concrete mix water, decreasing the allowable time between mixing and final compaction, and keeping the surface of the newly placed RCC pavement damp with a light spray during compaction and finishing operations.

C. No placement of RCC pavement shall be done while it is raining hard enough to be detrimental to the finished product. Placement may continue during light rain or mist provided the surface of the RCC pavement is not eroded or washed. Dump truck covers must be used during these periods. The ENGINEER will be the sole judge as to when placement must be stopped due to rain.

D. The subgrade shall be prepared according to Section GR – Grading. If required, construct a granular base according to Section GA – Graded Aggregate. Moisten the surface of the subgrade or base without creating mud or ponding water, to minimize absorption of water from RCC mix to be deposited.

E. RCC mixture shall be transported to the site in dump trucks with boxes cleaned out before loading and provided with protective covers properly secured in place until discharge. The trucks shall dump directly into the hopper of the paver unless placement is by hand, as directed by the ENGINEER. Hauling over the freshly placed RCC will not be permitted.

F. RCC delivery shall be coordinated so the mix can be spread and rolled within the specified time limit and to ensure uniform progress of the paver until the paving operation is complete. The time between plant mixing, and compacting shall not exceed forty-five (45) minutes, for all RCC placed, provided that the temperature of the RCC does not exceed 90°F. This time limit may be increased or decreased by the ENGINEER dependent upon ambient conditions of temperature and humidity.

G. Material shall be spread to sufficient depth to produce the specified thickness when compacted and shall conform to the required cross-sections and grade. Paver shall be operated in a manner that will prevent segregation and will produce a smooth continuous surface without tearing, pulling or shoving. Placing of the RCC mix shall be done in a pattern so that the water from previously placed RCC will not affect the fresh surface or subgrade. Broadcasting or fanning of RCC is not permitted.

H. For multiple lift placements, the CONTRACTOR shall submit a method of placement and lift thickness as part of the paving plan subject to the approval of the ENGINEER. In multiple lift construction, the second lift must be placed within 45 minutes of the completion of the first lift (time frame to be reduced to 30 minutes when ambient temperature exceeds 90°F). If more than 45 minutes has elapsed, the interface between the first and second lifts shall be considered a cold joint and shall be prepared in accordance with Section RCC-9.

I. If segregation occurs, paving operation shall be suspended until the cause is determined and corrected. Rake off segregated coarse aggregate before rolling. Broadcasting or fanning of RCC mixture onto areas being compacted is not permitted.

J. All RCC on both sides of the longitudinal joint formed by placing an adjacent lane, must be compacted within 45 minutes of plant mixing (time frame to be reduced to 30 minutes when ambient temperature exceeds 90°F), unless a cold joint is provided.

RCC-7 Compaction and Finishing

A. The CONTRACTOR is responsible for achieving 98% of the maximum wet density, as determined in the laboratory according to ASTM D 1557.

B. Compaction operations shall begin within fifteen (15) minutes after spreading of the RCC mix. If additional delay is incurred, the affected area shall be cored and tested at the CONTRACTORs expense to ensure that it meets the requirements of this Specification.

C. A rolling pattern shall be established that will achieve the required density with a minimum number of roller passes.

D. During vibratory compaction, the roller shall not be started, stopped, or left standing in vibratory mode. The stopping point of successive rolling passes shall be staggered to avoid forming depressions on the surface.

E. The RCC surface shall be continuously inspected while still plastic to ensure surface and grade tolerances are met. Excessive variations shall be immediately corrected in accordance with the spreading requirements.

F. Any roller marks on the surface shall be removed by finish rolling using a steel drum roller in static mode.

G. Each edge of each lane shall be constructed with a vertical or a 15-degree from vertical configuration.

RCC-8 Small Areas

A. Areas not accessible by the RCC paver shall be paved with other type material (asphalt or conventionally placed concrete, as shown on the plans).

B. Unless otherwise noted on plans, conventional poured concrete used for small areas shall have the same pavement section as adjacent RCC pavement.

RCC-9 Joints

A. A fresh joint is made when RCC mix is placed and compacted within 60 minutes of placing the previous lane. When creating a fresh joint, ensure that the contact face is moist and not segregated. Before rolling, hand-finish the joint as necessary to produce a tight surface. Roll extra passes as necessary to achieve the required density and smoothness in the joint area.

B. Any construction joint that does not meet the qualifications of a fresh joint is considered a cold joint. When creating a cold joint, sawcut the edge of previous lane back to sound RCC to form a vertical face. Place fresh grout on the vertical face just before placing fresh RCC against it. Before rolling, hand-finish the joint as necessary to produce a tight surface. Roll extra passes as necessary to achieve the required density and smoothness in the joint area. Every effort shall be made to maintain longitudinal joints as a fresh joint as described in "Fresh Joint" above. If using an Edging Shoe longitudinal joints may be a cold joint. Additional procedures, such as routing and sealing, may be required to longitudinal cold joints if the Edging Shoe does not form a vertical joint. This additional work will be performed at no additional cost to the Company.

C. Transverse joints shall be spaced at a maximum of 15 foot intervals or at intervals directed by the ENGINEER or as shown on the Plans. Contractor shall cut transverse joints to a depth 1/3 of the specified pavement thickness up to a maximum depth of 4". Transverse joints may be a fresh or cold joint as described above.

D. Prior to creating fresh longitudinal joints leave the outer 12 to 18 in. of the paving lane uncompacted during the initial rolling operation. This uncompacted edge is then used to set the height of the paver screed for paving the next adjacent lane. After the next adjacent lane is placed, the roller drum shall be centered over the joint and the adjacent lane edges shall be compacted simultaneously.

E. For multiple lift construction a horizontal joint shall be considered a fresh joint when a subsequent RCC lift is placed within 45 minutes of placement of the previous lift. This time may be adjusted at the discretion of the ENGINEER depending on use of retarders or ambient weather conditions. Fresh joints do not require special treatment other than cleaning the surface of all loose material and moistening the surface prior to placement of the subsequent lift.

F. The surface of horizontal cold joints shall be kept continuously moist and cleaned of all loose material prior to the placement of the subsequent lift. The ENGINEER may require other action such as use of a cement slurry or mortar grout between lifts. If supplementary bonding materials are used, they shall be applied immediately prior to placement of the subsequent lift.

G. Expansion joints shall be placed in the RCC pavement per the plans, in between conventional PC pavement and in between different pavement sections.

RCC-10 Curing

A. If no asphalt surfacing will be applied to RCC within 72 hours, keep the RCC surface continuously moist by water, fog spray, wet burlap, an approved membrane-forming curing compound, or polyethylene sheeting for a period of 7 days. Apply curing compound at 1-1/2 times the rate specified by the manufacturer.

B. If asphalt surfacing will be applied to RCC within 72 hours, immediately after final rolling, apply an asphalt emulsion per item 407 of the CMS. Apply at 1-1/2 times the rate specified by the manufacturer.

RCC-11 Tolerances

A. RCC pavement construction shall be subject to Sub-Section CP-15.

RCC-12 Quality Assurance and Control

A. Testing at the plant and the paving site is the responsibility of the CONTRACTOR and shall be performed by a private Independent Testing Laboratory approved by the ENGINEER. The CONTRACTOR and Supplier shall provide safe and convenient access, acceptable to the ENGINEER, for the inspection and sampling of the RCC and constituent materials, at both the production plant and the paving site, and shall cooperate in the inspection and sampling process at all times.

B. The CONTRACTOR shall construct a test section of a thickness equal to the design thickness with at least 100 tons of RCC. The test strip will be used to resolve anticipated problems with equipment, mix behavior, compaction, and/or strength characteristics. The test strip shall be constructed at a location chosen by the CONTRACTOR at least 30 days before the start of paving operations. The CONTRACTOR shall cooperate fully with the ENGINEER during construction and testing of the test strip. During construction of the test section, the CONTRACTOR will establish an optimum rolling pattern and procedure for obtaining a density of not less than 98% of the maximum wet density in accordance with ASTM D 1557. In addition, the CONTRACTOR must also demonstrate the ability to achieve a smooth, hard, uniform surface free of excessive tears, ridges, spalls and loose material. After completion of the test section, beams and cores will be extracted to verify mix compliance. This will be performed by the Independent Testing Laboratory, at the expense of the CONTRACTOR. During the trial placement, the Testing Personnel shall calibrate their nuclear density gauges in accordance with ASTM C 1040, with a sample of the test section mix. Moisture readings of the gauge shall be calibrated using oven dry samples of the plant-mixed RCC. If all aspects of the test strip have been previously satisfied, the ENGINEER may waive this requirement on a project-by-project basis.

C. The CONTRACTOR shall ensure quality control at the plant, by controlling materials, obtaining test samples and ensuring segregation is not occurring while loading haul trucks.

D. The private Testing Laboratory will develop a moisture/density relationship of the actual job materials in accordance with ASTM D 1557. Optimum moisture content, maximum dry and wet densities will be established.

E. Compressive Strength Testing: During the mix design development, the Independent Testing Laboratory shall produce six (6" x 12") diameter cylinders, in accordance with ASTM C 1435, to perform a 28 day compressive strength test of the material to verify mix conformance. Handling and curing shall be in accordance with ASTM C 31. The ENGINEER may require additional tests at different ages. Compressive strength testing shall be in accordance with ASTM C 39.

F. The CONTRACTOR, in cooperation with the Independent Testing Laboratory, shall ensure that compaction and grade specifications are met and time limits are adhered to.

G. Field Density: The Testing Laboratory shall perform density testing of the RCC in accordance with ASTM C 1040, direct transmission mode, as soon as possible, but no more than 30 minutes, after completion of rolling. Only wet density shall be used for evaluation. The required density shall be a minimum of 98% of the maximum wet density. At least 5 tests shall be performed for each 250 cubic yards placed. The CONTRACTOR shall be responsible for verifying required densities are achieved by the paver.

H. If density tests indicate that the material does not meet the required density, the ENGINEER, in collaboration with the CONTRACTOR and the Testing Laboratory, shall determine the source of the problem, whether mix properties, segregation, or gauge calibration. If mix properties have changed, or the concerns cannot be resolved, placement shall be suspended until the problem is corrected.

I. The Testing Laboratory shall core at least nine (9) 3-½ inch diameter cylindrical specimens from the interior of the slab for compliance verification. Length measurements of the cores and compressive strength testing shall be in accordance with ASTM C 42. The actual number of cores will be determined by the ENGINEER.

J. Testing will be conducted as follows:

1. Three (3) of the cores obtained for thickness verification will be tested for compressive strength at 28 days.

2. Three (3) of the cores obtained for thickness verification will be tested for splitting tensile strength at 14 days and tested also for density PCF.

3. Three (3) cores will be held for backup testing and/or further review as necessary.

4. At the option of the ENGINEER, the CONTRACTOR/Independent Testing Laboratory shall cut at least three (3) rectangular beams from the interior of the slab, in accordance with ASTM C 42, to perform a 14 day flexural strength test of the material. Additional tests at different ages may be required by the ENGINEER.

RCC-13 Defective RCC

A. All repairs are subject to the ENGINEERs approval. Correct deficiencies while RCC is still plastic; otherwise do repairs after seven (7) days. After seven (7) days, the RCC shall be removed by saw cutting full depth before removal. Replace the RCC utilizing a Cast-in-Place concrete meeting the requirements of Section CP – Concrete Pavement; Class B35-A, or fresh RCC that has been monitored at the plant for product quality, as directed by project ENGINEER. The new concrete shall be doweled into the existing RCC utilizing epoxy coated reinforcing bars unless the RCC option is utilized.

B. Remove and replace RCC if determined deficient in thickness set forth in the following procedure:

1. The Company reserves the right to determine the thickness of the concrete pavement by the measurement of cores cut at points on a random pattern established by the ENGINEER, with 1 core for every 2,000 square yards (1,672 m2) of pavement and a minimum of 3 cores. When cores are cut to determine the thickness of the concrete, the average thickness for the entire area of the project exclusive of any area with a deficiency of more than 1/2 inch (13 mm) shall not be more than 1/4 inch (6.4 mm) less than the specified thickness to secure full payment. All cores more than ½ inch (13 mm) greater than the specified thickness shall be considered as 1/2 inch (13 mm) more than the specified thickness. The average thickness of concrete on the entire project exclusive of any or all areas having a deficiency of more than 1/2 inch (13 mm) shall be considered to be the average depth of all cores taken with depths between the limits of ½ inch (13 mm) less than the specified thickness and 1/2 inch (13 mm) more than the specified thickness. All areas having an average deficiency of more than 1/4 inch (6.4 m) and not exceeding 1/2 inch (13 mm) shall be paid for at the rate of the average actual thickness to the specified thickness applied to the pay quantity for the item.

2. Payment will not be allowed for any area having a thickness deficiency of more than 1/2 inch (13 mm) as hereinafter defined. Should any core show a deficiency greater than 1/2 inch (13 mm), additional cores shall be cut 5 feet (1.5 m), measured longitudinally on each side of the deficient core, and additional cores shall be cut in a transverse direction on 1 or both sides of the deficient core in conformance to the previously determined pattern. If these additional cores are within the 1/2 inch (13 mm) tolerance, no further cores shall be cut for this particular area of deficiency. If either or both of the cores are not within the 1/2 inch (13 mm) tolerance, additional cores shall be cut at intervals of 50 feet (15.2 m), measured longitudinally, and also in a transverse direction as heretofore noted, from the core originally found to be deficient, until the thickness of the concrete is found to be within the 1/2 inch (13 mm) tolerance, but in no case shall such additional cores be cut beyond the location

of any core in that lane at which the thickness is found to be within the 1/2 inch (13 mm) tolerance. The area of thickness deficiency for which no payment is to be made shall be computed as the product of the width of the separately poured lane in which the deficiency occurs, or one-half lane width if the transverse cores are found to be within the 1/2 inch (13 mm) tolerance, by the sum of the distances, measured parallel to the center line, from the location of the core originally found to be deficient to the nearest boring in each direction which produced a core within the 1/2 inch (13 mm) tolerance.

C. Any RCC pavement found to be of unacceptable thickness, or deficient in any testing done according to this specification, may be subject to removal and replacement by the CONTRACTOR, at no cost to the Company, including removal and replacement of any intermediate and surface asphalt courses.

D. Grind off high surface variations to a finish acceptable to the ENGINEER.

E. Filling of low areas with fresh RCC is not permitted.

F. If asphalt surfacing is specified, low areas shall be made up with additional surfacing material without extra payment.

RCC-14 Asphalt Surfacing / Opening to Traffic

A. The RCC pavement may be asphalt surfaced as specified on the plans once the requirements of this specification have been met and all transverse contraction joints have been constructed.

B. If the RCC pavement is not to be asphalt surfaced immediately, all traffic shall be restricted from using the RCC until seven (7) days have elapsed or all strength requirements of this specification have been met. At any time prior to the expiration of the above mentioned seven (7) day period, the RCC may be asphalt surfaced as specified on the plans and then opened to traffic.

RCC-15 Warranty

A. This new process is being evaluated on a preliminary approval basis for use as pavement on Norfolk Southern projects. The preliminary approval period shall begin after the first installation of the new product and extend for a period of two (2) years thereafter. During this period, a two (2) year unlimited warranty shall be provided by the CONTRACTOR for each and every installation of this product.

B. In order for this warranty to take effect, the installation must have been performed in accordance with this specification and other applicable sections of the Norfolk Southern Standard Specifications for Materials and Construction.

C. At any time during the two (2) year evaluation period, and in the judgment of the Company, the product has failed to meet the specification requirements, the CONTRACTOR shall, at his expense, remove and replace the RCC base with the

applicable concrete pavement (Section CP – Concrete Pavement) and any intermediate/surface course(s).

RCC-16 Measurement and Payment

A. Measurement:

1. Measurement of roller compacted concrete pavement placed shall be number of finished square yards placed by type and thickness, as measured by the ENGINEER or as otherwise shown on the Plans or bid sheet..

2. All linear and surface area measurements shall be based on planimetric measurements (two-dimensional planar surface projection). No allowance shall be made for pavement cross-slopes, crowns, or other vertical features.

B. Payment:

1. Payment for RCC pavement will be made at the Contract unit price per square yard by type and thickness of pavement. This price shall constitute full compensation for furnishing and placing all materials, including reinforcing steel, transverse and longitudinal joints, expansion joint filler, silicone sealant, dowels or load transfer devices, curing materials and other material incidental to the work, preparation of the subbase as necessary, placing, finishing, curing, and all labor, equipment, tools, testing, supplies and incidentals necessary to complete the work.

2. No additional payment over the unit contract bid price will be made for any pavement which has an average thickness in excess of that shown on the plans.

3. No additional payment over the unit contract bid price will be made for hot or cold weather paving precautions.

END OF SECTION

Division IV: Track Systems

Section AS – Compressed Air Systems

Section BA – Ballast

Section TW – Trackwork

Section AS – Compressed Air Systems

AS-1 Description

Work consists of the CONTRACTOR providing a complete compressed air system as shown on the project Plans. Work shall include all required equipment, accessories, connections, incidental items, and labor necessary to complete the work. This section applies to both train air systems and tool/tire air systems.

The COMPANY shall size and furnish air receivers and containerized compressor systems, which will include the air compressor and supporting equipment. The CONTRACTOR shall install the air receivers and compressor containers.

AS-2 General

A. All valves and components are subject to approval by the ENGINEER prior to installation.

B. All materials shall be new and shall bear the manufacturer's name, trade name and the UL label in every case where a standard has been established for the particular material. The equipment and materials shall be essentially the standard product of a manufacturer regularly engaged in the production of the required type of equipment, and shall be the manufacturer's latest approved design.

C. CONTRACTOR-furnished equipment and materials shall be delivered to the site and stored by the CONTRACTOR in original containers suitably sheltered from the elements, but readily accessible for inspection by the ENGINEER until installed. All items susceptible to moisture damage (i.e., controls and electrical equipment) shall be stored in dry, heated spaces.

D. Equipment and materials of the same general type shall be of the same make and style throughout the work to provide uniform appearance, operation and maintenance.

E. Equipment and materials shall be tightly covered and protected against dirt, water, chemical or mechanical injury, and theft. They shall be thoroughly cleaned and polished in a condition satisfactory to the OWNER at the completion of the work. Damage or defects developing before acceptance of the work shall be repaired at the CONTRACTOR’s expense.

F. The CONTRACTOR shall ensure that the equipment and materials fit the space available. He shall make necessary field measurements to ascertain space requirements, including those for connections. He shall furnish and install such sizes and shapes of equipment so that the final installation suits the true intent and meaning of the drawings and specifications.

G. Manufacturers' directions shall be followed completely in the delivery, storage, protection and installation of all equipment and materials. The Contractor shall promptly

notify the Company in writing of any conflict between any requirements of the "CONSTRUCTION CONTRACT" or "SERVICE ORDER" and the manufacturers' directions and shall obtain the Company's written instruction before proceeding with the work. Should the Contractor perform any work that does not comply with the manufacturers' direction or such written instructions from the ENGINEER, he shall bear all costs arising in correcting the deficiencies

H. The CONTRACTOR shall furnish and install all equipment, accessories, connections, and incidental items to complete the work, ready for use and operation by the COMPANY.

I. CONTRACTOR shall prepare or construct pads and foundations for the air receiver and container as shown on the Plans.

J. The CONTRACTOR shall support all work and equipment plumb, rigid, and true to line. The CONTRACTOR shall study thoroughly all drawings, shop drawings and catalog data; he shall determine the supports, mounts or suspension of equipment, fixtures, piping, etc. He shall provide extra steel bolts, inserts, pipe stands, brackets and accessories for proper support whether or not shown on the drawings. When directed, the CONTRACTOR shall submit drawings showing supports for review by the ENGINEER.

K. All base mounted equipment shall have concrete pads that are 6 inches or more high. The pad shall project beyond the equipment on all sides enough to accommodate properly installed mounting and seismic supports. Equipment pad drawing details have precedence over this specification. Set anchor bolts after pouring of the slab. Chamfer all corners of each pad. Vertical exposed surfaces shall be filled, grouted, and rubbed. Apply a light broom finish. Concrete shall comply with ACI 304 “Recommended Practice of Measuring, Mixing, Transporting, and Placing Concrete” and as otherwise specified. All concrete shall be 3,000 psi at 28 days. Concrete shall not be placed in freezing weather unless some means of heating the forms and concrete to 70°F is provided for a minimum of 3 days.

L. The CONTRACTOR shall properly support all equipment, piping, and materials to withstand the design forces of the design seismic zone.

M. Unless otherwise noted on Plans, CONTRACTOR shall install all piping, valves, outlets, air receivers, containerized air equipment, and other items incidental to the air system.

N. Unless otherwise noted on Plans, the COMPANY shall furnish and the CONTRACTOR shall install the following equipment:

1. Air receiver with safety relief valve.

2. Containerized air compressor unit.

3. Gladhands and train line hoses for air stations.

AS-3 Piping

A. The Contract Drawings indicate the extent and general arrangement of the air compressor container, air outlets, pressure reducing station, air receiver tanks, pipes, etc. If any departures are deemed necessary by the CONTRACTOR, details of such departures and the reasons therefore shall be submitted to the ENGINEER for approval as soon as practicable and within 30 days after award of the Contract. No departure shall be made without written approval of the ENGINEER.

B. Materials:

1. Submittal data is required for any material different than specified.

2. Valves and Gauges:

a. Check valves 3" diameter and less shall conform to the following:

i. T-pattern swing check with replaceable, free-to-rotate bronze disk and threaded ends.

ii. Body and disk shall be cast bronze conforming to ASTM B62 C83600.

iii. Cap shall be cast bronze conforming to ASTM B16 C83600.

iv. Min. basic steam rating: 125 psi

v. Min. cold working pressure: 200 psi

vi. Max pressure rating: At least 250 psi

b. Check valves larger than 3" shall conform to the following:

i. Cast iron body swing check with flanged ends and bronze trim. Valve shall have replaceable bronze seat rings, disks, and hinge pins.

ii. Valve shall conform to ASME B16.1, MSS SP-71 Type 1 and MSS SP-25.

iii. Min. basic steam rating: 125 psi

iv. Min. cold working pressure: 200 psi

v. Max pressure rating: At least 250 psi

c. Pressure gauges shall conform to the following:

i. Glycerin-filled pressure gauge with 2-1/2" dial, ¼" NPT lower mount, and solid-front safety case designed for back blowout.

ii. Gauge shall have 316 stainless steel wetted parts and a stainless steel case.

iii. Pressure gauge shall have 0 – 200 psi range and 1.5% span of accuracy.

iv. Max pressure rating: At least 250 psi

d. Pressure reducing valves (regulators) shall conform to the following:

i. Inlet pressure range: 600 psi or as specified on Plans

ii. Outlet pressure range: 5 – 150 psi or a specified on Plans

iii. Internal pressure registration.

e. Pressure relief valves conform to the following:

i. Side-outlet relief valve with full nozzle design, stainless steel trim (nozzle and disc), O-ring seats, and cast bronze body.

ii. Valves shall have ball bearing pivots and dual control rings.

iii. Working pressures up to 250 psi.

f. Shutoff valves 2“ diameter and under shall conform to the following:

i. Three-piece self-exhausting full-port ball valve with threaded ends, carbon steel body, PTFE seats, 316 full-port stainless steel ball, stainless steel stem, and level handle.

ii. Lever handle shall include locking device to match service pressure.

iii. Conforms to MSS-SP-110.

g. Shutoff valves larger than 2” shall conform to the following:

i. Gate valve with cast steel body conforming to API 600, ASME B 16.34, ASME B 16.34, ASME 16.5, ASME 16.25, ASME B 16.10, and API 598.

3. Steel piping:

a. All steel pipe shall be schedule 40 black steel, continuous seam welded, unless otherwise shown, meeting API-5L with butt-welded connection. Minimum yield strength is 35,000 psi.

b. Underground steel piping shall be protected by an extruded polyethylene process, coated and tested per NAPCA Specifications. Underground risers and steel fittings shall be protected with extruded polyethylene primer and wrapping. Extruded polyethylene shall extend 6 inches aboveground and be electrically insulated from the pipe above ground through the use of insulating unions.

c. Steel piping intended for 110 psig or greater operating pressures shall only have welded fittings and joints.

d. Protect condensate drain lines with heat tape, insulating wrap, and metal jacket.

e. Risers shall be protected against damage by installing a coupling at a 6 inch invert elevation.

f. All threaded pipe joints shall be wrapped with plumbing tape. Screwed joints for steel pipe shall be made with tapered threads, properly cut. All burrs shall be removed. Pipe ends shall be reamed to full size of bore, and all filings removed. Joints shall be made tight with approved joint cement intended for the service encountered and applied to the male threads only. A maximum of 3 threads shall show after joint is made up.

g. Welded joints shall be fusion welded by qualified welders in accordance with ANSIB31.1 unless otherwise required. Mitering or notching pipes to form elbows and tees, and other similar types of construction will not be permitted. Saddle type welding outlets and reducing bushings are not acceptable. The CONTRACTOR will use only certified welders on the installation. The certifications will not be more than 12 months old and will be as prescribed by Section 9 of the ASME Boiler and Pressure Vessel Code.

h. Compressed air piping shall be steel where shown on the plans and details.

4. Polyethylene piping:

a. All underground polyethylene pipe and fittings shall be made of extra-high molecular weight high density polythelylene (EHMW-HDPE).

b. The polyethylene pipe and fittings shall meet the PE 3408 Black Pipe Specifications, ASTM D3035 and F-714, and PE-4710.

c. The polyethylene pipe and fittings shall be pressure rated at 73.4°F and have a design hoop stress of 800 psi. Fittings shall have the same pressure rating as the pipe.

d. The polyethylene pipe and fittings shall conform to SDR 9 and PE 4710.

e. The minimum design pressure for pipe shall be 250 psi at 73.4°F.

f. The polyethylene pipe shall be joined by heat fusion in the field.

g. Heat fused pipe joints shall meet or surpass the design pressure rating for the pipe.

h. The polyethylene pipe joint lengths shall be 40 feet unless otherwise specified.

i. The polyethylene pipe lengths, fittings, and flange connections to be joined by butt fusion shall be the same type, grade, and class of polyethylene resin and shall be supplied from the same manufacturer.

j. All piping under non-railroad roadways or mainline tracks shall be cased in accordance with specification. All casing piping shall be schedule 80 steel with an inside diameter at least 2 inches greater than the largest outside diameter of the carrier pipe joints or couplings. The inside diameter of the casing pipe shall be such to allow the carrier pipe to be removed subsequently without disturbing the casing or roadbed. Casing shall be installed to prevent the formation of a waterway under the railroad and with an even bearing throughout its length. The casing shall slope to one end.

k. SDR-9 polyethylene piping shall conform to the requirements shown in the following table:

Property	ASTM Reference	Nominal Value	Unit
Density (Pipe)	D-1505	0.955	$g/cm^{3.}$
Density (Natural Base Resin)	D-1505	0.943	$g/cm^{3.}$
Melt Index (Pipe, Condition E)	D-1238	0.1	g / 10 min.
Melt Index (Nat'l. Base Resin, Cond. E)	D-1238	0.1	g / 10 min.
Melting Point (Vicat Softening Temp.)	D-1525	255	°F
Brittleness Temperature	D-746	< -180	°F
Thermal Expansion	D-696	8 x 10^-5	in./in./°F
Thermal Conductivity	D177	3.5	btu-in/sf/hr/°F
"R" Value per 1" Thickness	-	0.3	R
Tensile Strength, Yield (2.0 in/min)	D-638	3,500	psi
Tensile Strength, Ultimate (2.0 in/min)	D-638	5,000	psi
Elongation (2.0 in/min)	D-638	> 800%	Percent
Modulus of Elasticity	D-638	113,000	psi
Flexural Modulus	D-3350	136,000	psi
Long-term Hydrostatic Strength	D-2837	1,600	psi
Hydrostatic Design Basis	D-2837	1,600	psi
Hydrostatic Design Stress	D-2837	800	psi
Hardness - Shore D	D-2240	63	-
Envir. Stress Crack Resistance - Cond. C	D-1693	>5,000	hrs.
ESCR (in 100% Natural Gas Condensate)	D-1693	>8,000	hrs.
Permeability, Natural Gas	-	0.16	cf/day/mi/atm

Table 1: Polyethylene pipe (SDR-9) Requirements

C. Installation:

1. All pipe welders shall be certified pipe welders with certificates.

2. All piping must be adequately supported and anchored.

3. All piping shall be cleaned on interior before securing in place. All piping shall be dry and protected from interior moisture, dirt and debris before, during and after construction.

4. All pipe connections shall be made with fittings.

5. Each air system shall include a full size nipple and valve at the air compressor to provide for connection to a mobile rental air compressor to the system while repairs are made.

6. Condensate drain line shall be protected with heat tape and insulating wrap and metal jacket.

7. All piping terminations at air compressor buildings, air receiver stations, air outlets, etc. shall be approved by the ENGINEER.

8. All underground piping shall be provided with magnetic tracing tape placed approximately 12 inches above piping.

9. Any changes in piping direction shall utilize a “tee” in lieu of a 90 degree fitting for possible extension in the future unless otherwise specified.

10. All above ground piping, including piping within the Compressed Air Buildings shall be provided with piping and flow markers per ANSI Standard A13.1, Scheme for the Identification of Piping Systems. Identify accessible piping installed indoors with pressure-sensitive piping system markers with wraparound seals. Identify piping installed outdoors with mechanically applied pipe marker. Markers shall be printed with weather-resistant ink. Markers shall include system name, flow arrow, color code and pipe diameter. Apply piping system markers adjacent to each valve and fitting, at each branch location, at each side of pipe passage through floors, walls, ceilings and partitions, at each pipe passage to and from underground areas and every 20 feet of run. Provide and incorporate arrow markers indicating direction of flow into or adjacent to each piping system marker. Use double-headed arrows if flow is in both directions. Apply piping system markers where view is unobstructed. Markers and legends shall be clearly visible from operating positions.

11. Apply piping system markers in accordance with manufacturer’s written instructions.

12. Placement of pipe in trench:

    a. Parallel pipes in the same trench must be spaced 6 inches apart.

    b. Underground piping shall have compacted granular material as shown on the Plans.

    c. Trenches shall be backfilled and tamped in 6” layer with mechanical tamper to 95% compaction before placement of ballast.

AS-4 Air System Vaults

A. Material Requirements:

1. Vaults shall be precast concrete (4,500 psi) and rated for HS-20 traffic loads.

2. Vault wall thickness shall be at least 6".

3. Vault lid shall be aluminum or ductile iron, lockable, and rated for HS-20 traffic loads with hinge assist. Hinges shall be stainless steel.

4. Vault shall conform to the following interior dimensions or as shown on the Plans:

   a. Regulator/air station vault: 24" x 24"

   b. Isolation valve vault: 42" x 24"

B. Installation:

1. Vault installation shall conform to the grades shown on the Plans or as directed by the Engineer.

2. Excavation shall be in accordance with Section GR – Grading.

3. Bedding material shall be placed and compacted to a minimum of 12".

4. Any damage to vaults caused by improper handling or backfill shall be repaired by the CONTRACTOR at no expense to the COMPANY.

AS-5 Testing and Cleaning

A. General testing requirements:

1. Before testing, complete installation of each pipeline, including final supports, hangers and anchors. Perform testing before insulation or paint is applied. Clean piping and equipment of metal cuttings and foreign matter as they are installed and in accordance with applicable codes and standards.

2. Submit test procedures and schedules to ENGINEER three (3) weeks before testing starts, and provide 24-hour notice prior to testing of specific systems. Test procedures and schedules shall be approved by ENGINEER. ENGINEER will witness and approve tests.

3. Perform testing before and after backfilling.

4. Piping systems shall be blown free of dirt and foreign material, using dry compressed air or nitrogen, prior to testing.

5. Pressure test piping to assure integrity of material and workmanship in accordance with the applicable ANSI/ASME Code for Pressure Piping (B31).

6. Pressure vessels, tanks, pumps, rotating and other mechanical equipment shall not be subject to the piping field pressure tests unless specifically designated by the ENGINEER, the Design Professional, or other Contract Documents.

7. Equipment, instruments and piping specialties which are not to be included in the test shall be either disconnected from the piping and the end of the pipe blanked off by a blind flange, plug or cap, or isolated by insertion of a line blind or spool piece as required.

8. Piping may be tested in sections or circuits as required for progress of Work.

9. Systems to be pressurized shall be provided with appropriate gages and pressure-relieving devices.

10. Lines containing check valves shall have source of test pressure located on the high pressure side of valves. Line control valves shall be set and maintained in wide-open position.

11. ENGINEER may waive pressure test for any reason. Such waiver shall be noted on Pressure Test Record. If either testing or witnessing is waived, a note shall be made for each line so waived.

12. CONTRACTOR shall maintain record of all tests. Test record shall show line designation, test pressure, ambient temperature, date of test, retests, and signature of the ENGINEER or ENGINEER's representative as witness.

B. Pneumatic Test Procedures: Pneumatic testing shall be done in accordance with ANSI/ASME B31.9 with the following clarifications:

1. Perform pneumatic test using either oil-free dry compressed air or dry nitrogen.

2. Prior to application of full pneumatic test pressure, a preliminary test at 10 psig shall be applied for a minimum of ten (10) minutes to reveal possible major leaks.

3. After preliminary test, apply pressure gradually in stages of not more than 25 psig until maximum test pressure is reached, allowing minimum of ten (10) minutes between stages to allow for strain equalization. Maintain test pressure for minimum of thirty (30) minutes without fluctuation; then reduce pressure to operating pressure and begin checking for leaks.

4. Check all joints, welds, valves and packing glands for leaks with a thick soap-water solution or with special fluid made specifically for this purpose and hold pressure for a minimum of eight (8) hours.

5. Repair leaks as specified under "Repair of Line Leaks".

6. Verify that adequate protection is provided to prevent injury to persons or property damage during leak testing.

C. Repair of Line Leaks: Comply with following procedures for repair of leaks. In each case, retest after repairs are made at no additional cost.

1. Soldered/Brazed Joints: Remove solder/brazing alloy and reapply with proper flux.

2. Flanged/Grooved End Joints: Check to determine flange/grooved end alignment and that all bolts are uniformly tightened with the required torque. If leak persists, depressurize the line, remove gasket, examine flange/grooved end faces, and insert new gasket.

3. Mechanical Joints: Remove existing mechanical joint coupling and insert new coupling.

4. Threaded Joints: Tighten joint to a reasonable torque. If leak does not stop, replace pipe and fittings as required. Do not use pipe dope, cement or seal weld to stop pipe leaks.

5. Sealant Joints: Remove existing sealant and reseal.

6. Gasketed Joints: Remove existing gasket and insert new gasket.

7. Welded Steel Joints: Repair pipe in accordance with ANSI/ASME B31.1.

8. Adhesive-Bonded Joints, Solvent-Welded Joints, Heat-Fusion Welded Joints, and Socket-Welded Plastic Joints: Replace joint.

9. Leaks in Material: Leaks located in pipe material shall require replacement of that section of pipe or fitting and repeat of test from the beginning. Sealant, welding or epoxy is not acceptable. Repair damage caused by leaks. Repairs and retest shall be made at no additional cost.

D. Cleaning: Cleaning shall be witnessed and approved by the ENGINEER. Clean compressed air lines with oil-free dry compressed air at design pressure through each section so that they are blown free of dirt and debris.

AS-6 Painting

A. General:

1. All painting shall be in accordance with the Steel Structures Paint Council Specifications for Paint Application and OSHA standards.

2. All finished surfaces shall be primed with one 3-4 mil coat of anti-rust compound. The prime coat shall be applied promptly after cleaning, but in no case shall the prime

coat be applied more than two hours after cleaning or after visible or detrimental rusting occurs.

3. Aboveground piping shall be painted with two 1.5 mil coats of Industrial Grade paint.

4. CONTRACTOR shall provide color chips to the ENGINEER prior to painting.

B. Application:

1. Air lines shall be painted according to the following colors:

   a. Between container and air receiver: Green

   b. Condensate piping: Blue

   c. All other air piping: OSHA Yellow

2. Container and air receiver tanks and piping shall have matching touch-up paint applied where damaged during shipment and installation.

3. No exterior painting shall be done when windblown dust or debris may contaminate the work. No paint shall be applied to wet surfaces.

4. No paint shall be applied when the temperature of the air or painting surface is below or expected to drop below the manufacturer's recommendations during the drying or curing time.

5. Nameplates, gauges, lubrication fittings, instruments and similar items shall be masked and otherwise protected as necessary to retain their original conditions.

6. Prepare surfaces by washing with solution of trisodium phosphate (4 oz. per gallon of water), rinse and allowed to dry. Use wire brush, power brush, or sand to remove loose scale, rough surfaces, and rust.

7. The prime coat shall be applied promptly after cleaning, but in no case shall the prime coat be applied more than two hours after cleaning or after visible or detrimental rusting occurs.

8. All applications shall be made with brush or roller. All coats shall be products of the same manufacturer.

9. Paint shall be mixed and applied in compliance with the manufacturer's directions. Paint materials shall be thoroughly stirred until the ingredients therein are completely intermixed and, if necessary, strained prior to being applied. Thinners, if used, shall be those furnished or recommended by the paint manufacturer for the application conditions. Thinner shall not be used in excess of the manufacturer's recommendations.

10. The manufacturer's recommendations for recoat time for the conditions under which painting is performed shall be strictly followed.

11. The CONTRACTOR shall remove all paint spots or stains caused by his work, leaving all surfaces in an acceptable condition. CONTRACTOR shall do all retouching and refinishing of any work or surfaces of the work which may be damaged or found defective.

AS-7 Measurement and Payment

A. Measurement:

1. Air receivers and compressor containers shall be measured on a per-each basis per air system installed.

2. Compressed air lines furnished, installed, and tested as shown on the Plans and in accordance with these specifications shall be measured by the linear foot for the type and diameter installed. All material, excavation, backfill, warning tape, granular fill, and labor shall be included.

3. Compressed air stations shall be measured per each for each type and size.

4. Air system vaults shall be measured per each for each type and size.

B. Payment:

1. Payment for air receivers and compressor containers shall be paid per each at the Contract unit price. Price shall include receiving, installing, electrical wiring, air line connections, painting above-ground pipes, touch-up painting, and labor costs. Price shall also include condensate tubing and all air lines between the receiver and compressor. Unless otherwise noted in the Contract documents, the COMPANY shall furnish the containerized air compressor system and air receiver.

2. Payment for air lines shall be paid on a linear foot basis at the Contract unit price for each type and diameter installed. Price shall include all material, excavation, backfill, warning tape, granular fill, and labor necessary.

3. Payment for compressed air stations shall be paid on a per each basis at the Contract unit price for each type and size installed. Price shall include all material, excavation, backfill, valves, and labor necessary.

4. Payment for concrete foundations and slabs shall be paid in accordance with section SC – Structural Concrete.

5. Payment for air system vaults shall be paid per each at the Contract unit price for each type and size of vault installed. Price shall include material, installation, excavation, backfill, hatch, painting, and labor costs. Price shall also include all air line piping,

valves, regulators, fittings, and other appurtenances within the vault for a complete installation.

END OF SECTION

Section BA – Ballast

BA-1 Description

The work covers production, delivery, and installation of railroad ballast. Responsibility for purchase, transportation, and handling of material shall be as specified in the project contract document.

BA-2 General Conditions

A. Two categories of railroad ballast for use in the track structure are specified:

1. Mainline ballast, for use in all tracks other than designated yard tracks as shown on the plans, or as directed by the ENGINEER.

2. Yard ballast, for use in all designated yard tracks as shown on the plans, or as directed by the ENGINEER.

B. All ballast must originate from a COMPANY-approved quarry.

C. All ballast shall be approved by the ENGINEER prior to installation in the track structure. Ballast gradation deficiencies or quality imperfections not visible due to storage or stockpiling shall be inspected and corrected as described in Section BA-5, paragraph H, of these Specifications.

D. Ballast material type (granite or limestone) shall be as specified on the plans. If unspecified, granite is to be used, unless an alternate material is approved by the ENGINEER.

E. Additional references:

1. Norfolk Southern MW&S Standard Procedure 020 – BALLAST: Use, Unloading, and Reporting.

2. Norfolk Southern Specification #702 – Prepared Stone Ballast.

BA-3 Material Quality

A. Prepared ballast shall be crushed stone composed of hard durable particles, free from objectionable amounts of deleterious substances and conforming to the requirements of this specification.

B. Prepared ballast shall meet the following specifications:

1. Gradation, as determined using ASTM C 136, using square opening sieves conforming to ASTM E 11. One test shall be performed each 1000 tons or fraction thereof of material loaded for delivery.

a. Mainline ballast shall comply with the NS-modified AREMA gradation #3, as shown in Table 1 below.

b. Yard ballast shall comply with the AREMA gradation #5, as shown in Table 1 below.

Percent Passing Standard Sieve Size by Weight									
Type	**2 1/2"**	**2"**	**1 1/2"**	**1"**	**3/4"**	**1/2"**	**3/8"**	**#4**	**#200**
AREMA #3 Mod.	100	95-100	30 - 65	0 - 15	. . .	0 - 5	. . .	. . .	0.5 max.
AREMA #5	. . .	. . .	100	90 - 100	40 - 75	15 - 35	0 - 15	0 - 5	0.5 max.

Note: All gradation testing shall be performed according to AASHTO T-27.

Table 1: Ballast Gradations

2. Clay lumps and friable material - percentage as determined by ASTM C 142 shall not exceed 0.5%.

3. Material finer than #200 sieve - percentage as determined by ASTM test C 117 shall not exceed 0.5%.

4. Absorption - as determined by ASTM C 127 shall not exceed 1.0%.

5. Sodium sulfate soundness - average weighted loss after five (5) cycles shall not exceed 2.5%, as determined by ASTM C 88.

6. Resistance to degradation - as determined by ASTM C 535, grading type 2, (Los Angeles Abrasion Test 535-2) shall not result in a wear percentage greater than 27.5% for granite, or 25.0% for limestone.

7. Flat and/or elongated particles - as determined by ASTM D4791-89, using a 3:1 ratio shall not exceed 5.0%.

8. Rock cementing value (limestone only) shall not exceed 200 psi. The test shall conform to the following procedure:

   a. Take 350 grams of stone dust passing #100 mesh sieve. Dust is obtained by running approximately one (1) quart pea size stone chips (retained on #4 sieve, passing 3/8" sieve) in standard LA Abrasion machine for 10,000 revolutions, or 5 to 6 hours at 30 to 33 rpm with three (3) standard ASTM C 535 balls.

   b. Place dust on glass surface, make a crater, add approximately 70 cc water, cover and allow to absorb for one (1) minute. Wearing rubber gloves, mix roll, and knead for five (5) minutes to obtain a stiff dough. Adjust amount of water to obtain this. Place in an air tight can for two (2) hours.

c. Mold ten (10) standard 1" diameter x 1" high cylinders. Weigh about 30 to 31 grams stiff dough (or sufficient to obtain cylinders 1" plus or minus 1/32" high) in balance. Place mold and compress with 1475 lbs (1877.5 psi), holding load constant for one (1) minute.

d. Air dry cylinders for 20 hours at room temperature, then for four (4) hours in hot air bath at 212°F. Place immediately in a desiccator for 20 minutes and then test in compression testing machine with pivoted or ball socket head for uniform load distribution. Load is applied at 600 lbs. per minute.

e. Report average crushing strength in psi as cementing value of stone. Calculation: PSI = Load / 0.7854.

C. CONTRACTOR shall furnish a certification of compliance stating that the material meets or exceeds the requirements of the specification. For sources not currently approved by the COMPANY, the CONTRACTOR shall provide independent certification as required by the COMPANY.

D. Graded aggregates subject to on site stockpiling prior to placement shall be reblended as directed by the ENGINEER to ensure compliance with the original gradation specified.

BA-4 Delivery

A. If ballast is specified by project contract to be furnished by the CONTRACTOR:

1. Rail Delivery:

a. The CONTRACTOR shall be responsible for arranging rail delivery and unloading using cars furnished by Norfolk Southern Railway.

b. The CONTRACTOR is responsible for all freight charges.

c. If direct unloading of ballast is not possible, the CONTRACTOR shall be responsible for arranging rail delivery to the nearest available track. The CONTRACTOR shall be responsible for prompt unloading of the cars and for the transport of the material to the job site for installation or stockpiling.

2. Truck Delivery:

a. The ENGINEER, or person(s) designated by the ENGINEER, shall collect quarry tickets for each load of ballast delivered to the job site by truck.

B. If ballast is specified by project contract to be furnished by the COMPANY:

1. The ballast will be transported in COMPANY-owned gondola, hopper, or side discharge cars.

2. If direct unloading of ballast is not possible, the ballast will be delivered to the nearest available track. The CONTRACTOR shall be responsible for prompt unloading of the cars and for the transport of the material to the job site for installation or stockpiling.

C. The ENGINEER may refuse acceptance, at no cost to the COMPANY, if the material being supplied is unsuitable or not in accordance with these Specifications.

D. If material is stockpiled, CONTRACTOR shall limit the movement of wheeled or tracked machines over the material.

BA-5 Installation

A. All ballast shall be placed in accordance to project plans, using standard railroad construction practices and equipment. Changes or substitutions must be approved in advance of installation by the ENGINEER.

B. Installation shall also be governed by the Section TW - Trackwork of these Specifications.

C. Ballast that is contaminated by foreign material during stockpiling or construction will not be used in track. Contaminated material shall be removed prior to tamping.

D. Ballast that becomes segregated by field stockpiling will be reblended to specification prior to placement in track.

E. Ballast section depth, width, and slope shall conform to typical section(s) shown on the plans. The CONTRACTOR shall be required to add or remove ballast from the track section if deemed necessary by the ENGINEER.

F. If placement of an engineering fabric beneath material is specified on the plans, it shall be installed in compliance with Section "EF - Engineering Fabrics" of these specifications. Placement of material on fabric shall be done in a manner that shall not damage or destroy the fabric. CONTRACTOR shall be responsible for repairs to the fabric if it is damaged.

G. Damage to completed ballast layers/section caused by the CONTRACTOR during subsequent operations shall be repaired by the CONTRACTOR at his expense prior to acceptance of work by the COMPANY. This shall include, but is not limited to, rutting, inter-mixing of foreign materials, or disturbance of finished shoulders.

H. Any CONTRACTOR furnished material which is placed and then subsequently determined by COMPANY conducted material testing to not be in compliance with the Specifications shall be removed as directed the ENGINEER at no cost to the COMPANY.

BA-6 Measurement and Payment

A. Measurement and payment for CONTRACTOR furnished ballast shall be as follows:

1. Material delivered by rail shall be measured by the ton. The quantity shall be determined from the total weighbills for each car load or the billing invoice from the quarry to the CONTRACTOR.

2. Material delivered by truck shall be measured by the ton. The quantity shall be determined from the total weigh slips for each vehicle load weighed upon an approved standard scale or from digital print-out slips from an automatic batching plant. Weigh slips shall be collected by the ENGINEER or his representative.

3. Payment for CONTRACTOR furnished material shall be at the contract unit bid price per ton, which price shall be full compensation for all labor, equipment and tools required to furnish, transport and stockpile the material. Payment for placing the material shall be included in the payment items included in Section TW-Trackwork of these Specifications.

4. If material is rail delivered, CONTRACTOR shall be responsible for rail freight charges.

B. There shall be no separate payment for CONTRACTOR's unloading, transporting or stockpiling COMPANY furnished material. Payment for unloading, transporting, stockpiling and placing the material shall be included in the payment items included in Section TW - Trackwork.

C. There shall be no payment to CONTRACTOR for any portion of the CONTRACTOR furnished material which is placed and then subsequently determined by COMPANY conducted material testing to not be in compliance with these Specifications. Removal of the material shall be at the CONTRACTOR's expense.

END OF SECTION

Section TW – Trackwork

TW-1 Description

The Work shall consist of continuous welded rail and/or jointed track construction, panel track construction, crane track construction, panel turnout installation, turnout construction and installation, derail construction and installation, switchtie installation, upgrading of existing track which shall include rail and crosstie installation, surfacing, track lining, relocation of turnouts, and the removal of track and turnouts.

TW-2 General

A. All track materials shall be furnished to the CONTRACTOR by the COMPANY unless otherwise specified in the project Contract documents.

B. The COMPANY shall endeavor to set up and maintain a steady flow of materials to the CONTRACTOR. The COMPANY will not guarantee such delivery and will not assume any obligation, monetary or otherwise, to the CONTRACTOR if materials are not delivered to the site in accordance with planning or scheduling by the CONTRACTOR or COMPANY.

C. The CONTRACTOR shall be responsible for the materials furnished him until they are incorporated into the Work. Loss of any part of the materials by theft or otherwise shall be either replaced by the CONTRACTOR at his expense or be replaced by the COMPANY with the cost thereof deducted from the final payment made to the CONTRACTOR.

D. The COMPANY shall furnish ballast for surfacing of the tracks unless otherwise specified in the project Contract documents. Ballast shall be delivered to the jobsite in ballast or hopper cars.

E. Material furnished by the CONTRACTOR shall be approved by the ENGINEER.

F. No track shall be laid until the roadbed (subgrade and subballast) is completed and approved by the ENGINEER.

G. Main line turnouts and turnouts from active tracks shall be installed by COMPANY forces.

H. Turnouts to be installed by the CONTRACTOR shall be as noted on the plans and bid sheet.

TW-3 Unloading and Handling of Materials

A. All track material furnished by the COMPANY shall be delivered to the job site for unloading by the CONTRACTOR.

B. Material shall be handled in such a manner as to insure against damage.

C. Picks shall not be used in the handling or moving of crossties.

D. The CONTRACTOR shall unload, store and protect all COMPANY material and release the railroad cars within 48 hours of delivery or pay demurrage.

E. Track material not delivered to the job site shall be delivered at a location designated at the job showing for unloading and delivery to the job site by the CONTRACTOR.

F. CONTRACTOR shall provide assistance in unloading welded rail strands (approximate length 1,440 feet) from the rail train. The rail shall be accepted by the CONTRACTOR as it is unloaded, and it shall be the duty of the CONTRACTOR to store and/or install the rail in accordance with these Specifications.

G. Jointed rail, when used, shall be unloaded or loaded with an approved derrick or crane without dropping, and if stacked shall be placed with the heads up and with sufficient support under the base.

TW-4 Continuous Welded Rail and/or Jointed Rail Construction

A. The CONTRACTOR shall construct, ballast, line and surface the track to the final grade and alignment.

B. The CONTRACTOR shall be responsible for the track until the track is accepted by the ENGINEER.

C. Wood crosstie installation shall conform to the following:

1. Crossties shall be spaced 20 inches center to center, and laid at right angles to the track centerline with the end measuring 1 foot 10-3/4 inches from the end of the tie to the gauge line of the rail.

2. The bearing surfaces of the crossties shall be clean before tie plate and rail installation.

D. Wood crosstie installation shall conform to the following:

1. All crossties shall be fully tie plated before the rail is laid.

2. The bottom of the tie plates shall be cleaned before the plate is applied.

3. Tie plates shall be applied with the 1:40 cant down towards the center of track.

4. The tie plate shall be spiked to gauge, not greater than every third crosstie, and shall be set so that the outside shoulder of the tie plate shall bear squarely against the base of the rail, having a full bearing for the rail and, at the same time, a full bearing on the crosstie.

5. Track spiking shall adhere to the following procedures:

    a. Spiking patterns shall conform to Norfolk Southern's MW&S Standard Plan 7-03.

    b. When re-spiking is performed, old spike holes must be plugged with wood or approved liquid plugging material unless otherwise approved by the ENGINEER.

    c. Before spikes are driven, ties must be properly spaced and square to the rail. When tie plates are installed, they must be centered on the tie and provide full bearing.

    d. Spikes may be driven with a standard spike maul or with a machine. Spikes must be started and driven vertically and square to the tie to provide a full bearing at the base of rail.

    e. When spiking, care must be exercised not to strike the rail, other fastenings, or signal appliances.

    f. Special trackwork such as frogs, point section of turnout, frog guardrails, crossings, etc. must be fully spiked in all plate holes provided.

E. Steel crosstie installation shall conform to the following:

1. Steel crossties shall be spaced 24 inches center to center on tangent tracks and 20 inches center to center on curved track and laid at right angles to the track centerline

2. The bearing surface of the crossties shall be clean before tie installation.

F. Continuous welded rail installation shall conform to the following:

1. Installation of the continuous welded rail shall be done with off track equipment as to not interfere with the operation of main line traffic.

2. Although the COMPANY shall endeavor to unload the rail in the approximate final location, it shall be the duty of the CONTRACTOR to position the rail in its final location which may require moving the welded rail strands.

3. The following rail temperature criteria shall apply:

    a. Prior to laying continuous welded rail, the COMPANY shall determine and record the maximum and minimum rail temperatures in the area, as laying procedures are dependent on the total range of temperatures to be experienced by the rail. [The desired rail laying temperature range is 85°F to 100°F, ideally 95°F.]

    b. When it is not possible to lay the rail at the desired laying temperature, the CONTRACTOR shall record the temperature of each rail laid and make the necessary adjustments. If adjustment cannot be achieved naturally, use of a rail heater will be required. All adjustments shall be as approved by the ENGINEER.

c. The CONTRACTOR shall be required to keep an accurate record of rail temperatures taken three times daily (morning, noon and afternoon). Rail temperature report chart shall be furnished to the CONTRACTOR by the COMPANY.

4. If relay continuous welded rail is laid, the rail shall be laid so that the least worn side of the head of the rail is on the gauge side.

5. Continuous welded rail shall be handled in such a manner as to prevent bending and damaging the rail. Any rail damaged by the CONTRACTOR, due to mishandling, shall be replaced at the CONTRACTOR's expense.

6. The bottom of the rail shall be cleaned before the rail is laid.

7. Strands of continuous welded rail shall be connected by 36 inch joint bars and bolts as directed by the ENGINEER. In some cases only the outside holes will be drilled for later thermite welding. Continuous welded rail shall be laid without expansion gaps at the joints. Joints are to be suspended to allow for thermite welding. Joints are not allowed in continuous welded rail on or within 234 feet of open deck bridges except those associated with expansion joints.

8. The CONTRACTOR shall not be required to field weld joints.

9. Flame cutting of rails or burning of bolt holes with a torch shall be prohibited. Rails shall be cut with a rail saw only. Bolt holes shall be drilled with a rail drill only. Any COMPANY or Industry owned rail which is flame cut by the CONTRACTOR shall be replaced by the CONTRACTOR at his expense.

G. Jointed rail installation shall conform to the following:

1. Joints in opposite rails shall be staggered between 1/4th and 1/3rd of a rail length apart, except as close joints may be required at insulated joints or turnouts.

2. Short rail, not less than 15 feet long, may be used in adjusting for proper spacing of joints.

3. Proper allowance for expansion should be provided at rail joints.

4. Relay jointed rail shall be laid so that the least worn side of the rail is on the gauge side.

H. Joint bar installation shall conform to the following:

1. Joint bars shall be clean of any foreign material, except metal preservative, and properly installed with the full number of and correct size of bolts, nuts and spring washers.

2. Before placing joint bars, the bearing surfaces of the bars as well as the rail ends within the joint bar area shall be free of any foreign material except metal preservative.

3. Bolts placed with nuts alternately on inside and outside of rail shall be drawn tight before spiking.

4. Where possible, all joints shall be kept out of road crossings.

5. Before acceptance of work, all bolts shall be checked by the CONTRACTOR and, if necessary, tightened.

I. Final gauging for wood ties shall conform to the following:

1. Necessary final gauging shall be done after the rail is laid and jointed.

2. Before spikes are driven, crossties shall be evenly spaced and square to the rail. Tie plates shall be centered on the tie and provide full bearing.

3. When spiking, care shall be exercised not to strike the rail.

4. The final gauge shall be 56-1/2 inches.

5. Track shall be gauged as spikes are driven home.

6. Any crossties that do not fully bear on the subballast shall be nipped up while spiking.

7. When constructing skeleton track, final gauging and anchor spiking shall not be performed until after the track is lined to final alignment.

J. Final gauging for steel ties shall conform to the following:

1. The final gauge shall be 56-1/2 inches.

2. Any crossties that do not fully bear on the subballast shall be nipped up prior to installing clip.

K. Anchor and double spiking on wood ties shall conform to the following:

1. Track curvature shall be spiked as shown on the plans.

2. Drive screw spikes shall be used for anchor spiking of curves if specified on the plans.

3. When driving spikes in secondhand crossties, tie plugs shall be placed in all holes before driving spikes.

4. All spikes shall be started and driven perpendicular to the crosstie and square with the rail and so driven that the head of the spike shall have a full hold on the base of rail or the tie plate when anchor spiking.

5. Spikes shall not be overdriven so that the lip of the spike head bends upward.

6. No spikes shall be driven at the ends of joint bars.

7. The CONTRACTOR shall remove any overdriven spikes or spikes that are bent while driving. Tie plugs shall be placed and then spikes properly driven.

8. Relay spikes shall be used for all anchor spiking of tie plates. The CONTRACTOR shall straighten all relay spikes before use.

L. Rail anchor installation for wood ties shall conform to the following:

1. For jointed rail every fourth crosstie shall be box anchored.

2. For continuous welded rail box anchor as follows:

   a. Every other crosstie on tangent track and curves less than 3°.

   b. Every crosstie on curves 3° or greater.

   c. Every crosstie 234 feet on each side of a joint.

3. When continuous welded rail connects to jointed rail, the first 234 feet of jointed rail shall be box anchored for every crosstie except at, and opposite joints. The next 234 feet of jointed rail shall be anchored with a transition pattern between the continuous welded rail and the jointed rail pattern.

4. At open deck bridge locations, the ground track shall be box anchored every crosstie for 234 feet from each bridge end. Where expansion joints are located on the ground track, the track shall be box anchored for every crosstie from the expansion joint away from the bridge. There shall be no anchors or track joints between the expansion joints and the bridge.

5. Box anchoring shall include 4 anchors per crosstie. All anchors shall be secure on the base of rail and be snug against the crosstie.

M. Ballasting shall conform to the following:

1. Ballast delivery and installation is also governed by section BA - Ballast.

2. The COMPANY shall supply ballast to the CONTRACTOR in COMPANY ballast or hopper cars. CONTRACTOR shall unload the ballast promptly upon delivery to the job site.

3. CONTRACTOR shall be responsible for unloading, hauling, transferring, spreading, tamping and dressing ballast.

4. Ballast shall be uniformly distributed as it is unloaded by the CONTRACTOR after anchoring of the track has been completed.

5. The depth of preliminary ballast for surfacing shall not be more than 4 inches between the bottom of crossties and the top of subballast. Each successive raise shall not exceed 4 inches.

6. The final ballast raise shall not exceed 2 inches.

7. Care shall be taken to avoid disturbing or destroying any centerline or top of rail stakes.

8. The CONTRACTOR shall dress ballast to conform to typical roadbed sections as shown on the plans.

N. Surfacing shall conform to the following:

1. A preliminary surfacing shall follow each unloading of ballast.

2. The CONTRACTOR shall thoroughly tamp (surface) track with an on-track power (mechanical) tamper.

3. If jacks are used they must be placed close enough together to prevent undue bending of rails or strains at joints.

4. Both rails must be raised at one time as uniformly as possible.

5. For wood ties, the track shall not be raised more than 4 inches per lift. Ballast must be well tamped from a point 15 inches inside of each rail, on both sides and under the crosstie, to the end of the crosstie.

6. For steel ties, the track shall be raised at a minimum of 4 inches for the first lift as measured from the bottom of flange to subballast. The ballast shall be well tamped the entire length of each crosstie with a tamper that has a moveable head.

7. Ballast shall be well tamped under each tie before subsequent lifts are made.

8. All crossties that are pulled loose shall be restored to proper position and secured before tamping.

9. The CONTRACTOR shall raise the track to the final profile grades with the necessary additional ballast mechanically tamped under the crossties.

O. The alignment for the track shall not deviate from uniformity more than 1/8 inch at the mid-offset in any 62 foot line on tangent track or more than 1/8 inch mid-offset in any 62 foot chord on curved track.

P. Track surface may not deviate from uniformity more than the following:

1. The deviation from design profile on any rail at the mid-ordinate of a 62 foot chord may not be more than 1/8 inch. Cross level must be maintained.

2. Curved track shall be superelevated as shown by the plans. Deviation from superelevation on spirals may not be more than 1/8 inch.

Q. Upon completion of the final surfacing and lining of the track, the CONTRACTOR shall trim the ballast to conform to the typical roadbed section as shown on the plans, and dispose of any surplus ballast as directed by the ENGINEER. The completed ballast section shall have all tie cribs filled, and crossties, tie plates and rails shall be swept clean.

R. Build-up of rail ends shall conform to the following:

1. Build-up of rail ends is not allowed unless requested by the ENGINEER.

2. The CONTRACTOR shall attempt to match rail section as much as possible. A variation of 3/32 of an inch or more in head wear must be built-up.

3. A runoff of 4 inches must be made for 3/32 of an inch of build-up, with an additional inch of runoff for each additional 1/16 of an inch of build-up.

4. All welding work must be performed only by personnel that have been approved and cleared by the ENGINEER.

5. Joints to be built-up shall be marked and approved by the ENGINEER.

6. Any joint that does not require welding but is slightly mismatched shall be ground smooth.

S. The sawing and drilling of rail ends shall conform to the following:

1. The CONTRACTOR shall, as directed by the ENGINEER, saw out defective or worn segments of rail and all rail ends that have been torch cut or otherwise damaged.

2. The saw cut shall be made at least 12 inches behind the cut when removing torch cuts.

3. All cuts shall be true and vertical with the cut through the entire rail section.

4. Rail ends shall be drilled as shown on the plans.

TW-5 Panel Track Construction

A. The COMPANY may elect to furnish panel track for new track construction. Panels shall consist of preassembled units of one rail length including rails, crossties, tie plates, spikes and anchors.

B. The CONTRACTOR shall unload panels and construct track in accordance with subsection TW-4.

C. Once panels are in place and connected, joints shall be staggered. To accomplish this, rails on one side shall be moved in unison along the tie plates and the resulting gap shall be plugged with a short rail section.

D. The CONTRACTOR shall straighten any skewed crossties and shall install any crossties that are missing.

E. The CONTRACTOR shall install any extra rail anchors required.

TW-6 Crane Track Construction

A. Crane track shall be constructed as shown on the plans.

B. If required by the ENGINEER, prior to placing ballast, the CONTRACTOR shall compact or regrade trench in subballast for construction of crane track in asphalt paved areas.

C. The CONTRACTOR shall unload, spread and compact ballast. The preliminary depth of ballast shall be one-half of the total depth but not more than 4 inches.

D. Crossties shall be spaced 20 inches center to center on top of the ballast and the track constructed in accordance with subsection TW-4.

E. If precut crossties are unavailable, the CONTRACTOR shall cut COMPANY furnish standard crossties to lengths of 4 feet 3 inches.

F. Crane track shall be fully anchored and fully spiked before raising to final surface.

G. The crane track shall be raised to final surface with hand jacks and tamped with hand mechanical tampers.

TW-7 Panel Turnout Installation

A. Panel turnouts shall be furnished by the COMPANY as two or three preassembled units and shall be unloaded by the CONTRACTOR at a point as near as possible to the point of installation.

B. The CONTRACTOR shall be responsible for supplying all necessary equipment and labor required to move the units to the proper location, make final connection of the separate units and to install the turnout at the designated point in the track structure.

C. Track gauge at the point of switch shall be 57 inches.

D. Three gauge rods shall be installed ahead of each switch point after the turnout has been installed. Insulated gauge rods must be used where signal circuits exist.

E. All hand throw stands, targets, and hold-down latches are to be set by the CONTRACTOR and adjusted so that the points operate freely and fit tightly against the stock rail when in a closed position.

TW-8 Turnout Construction and Installation

A. The COMPANY may elect to provide loose turnout materials. The CONTRACTOR shall assemble the turnout on the prepared roadbed in close vicinity to its final location.

B. Turnout construction shall be as shown on the plans.

C. No turnout shall be constructed without COMPANY supervision.

D. All rails for turnout construction, except for stock rails, shall be cut by the CONTRACTOR from COMPANY furnished rail.

E. For wood crosstie turnouts, install anchors as follows:

1. For mainline turnouts, diamonds, and turnouts on welded rail, fully box anchor all switchties, except at switch points and frogs. In addition, box anchor every effective tie in each direction for six 39-foot rail lengths on both sides of the turnout.

2. For non-mainline turnouts and turnouts in jointed rail, box anchor every other switchtie, except at switch points and frogs. In addition, box anchor every other crosstie for three 39-foot rail lengths on both sides of the turnout.

F. For steel crosstie turnouts, all drilling required to construct turnout must be performed using a magnetic drill.

G. Completed turnouts shall be installed in accordance with subsection TW-7.

TW-9 Derail Construction and Installation

A. The CONTRACTOR shall construct and install double switch point derails in accordance with the plans using COMPANY furnished materials. No double switch point derail shall be constructed or installed without COMPANY supervision.

B. The CONTRACTOR shall install Model HB or EB derails, as specified, in accordance with the plans.

TW-10 Switchtie Installation

A. The CONTRACTOR shall remove unsuitable switchties and install new or previously used switchties, furnished by the COMPANY, in existing turnouts as designated by the ENGINEER.

B. Switchties shall be installed prior to any necessary surfacing.

C. Switchties shall be equally spaced between adjacent switchties and at right angles to the straight side track centerline.

D. All switchties shall be box anchored on each rail, except at switch points and frog. Any anchors removed or dislodged during changing out of switchties shall be replaced.

E. Previously used switchties to be installed shall be plugged prior to spiking.

TW-11 Track Upgrade

A. The CONTRACTOR shall upgrade existing track as shown on the plans or as directed by the ENGINEER. The work shall include the installation of new crossties, placement of tie plugs, replacement of rail and other track materials, unloading of ballast, tamping and surfacing and lining and gauging of track as required.

B. Disposition of removed materials shall be in accordance with subsection TW-15.

C. In the process of upgrading tracks it may be necessary to perform work while the existing track is in service. The COMPANY shall provide a schedule for the period of work allowed, and the CONTRACTOR shall progress his work to allow for the movement of trains at the end of this scheduled time period. The COMPANY shall try to schedule the movement of trains to provide the maximum time available for the CONTRACTOR to work; however, the CONTRACTOR shall make no claims for extra compensation due to delays, or extra work incurred to allow for the passage of trains.

D. The removal and replacement of rail shall conform to the following:

E. The CONTRACTOR shall remove all spikes from crossties, tie plates, rail anchors, joints, bolts and nutlocks as necessary to release the existing rail.

1. Unloading, handling and installation of the rail shall be in accordance with subsection TW-4.

2. All crossties shall have spike holes filled with wooden plugs and be respiked.

F. The removal and installation of crossties shall conform to the following:

1. Crossties to be replaced shall be as indicated by the ENGINEER.

2. The CONTRACTOR shall install new crossties in existing track prior to surfacing track and after installing rail, if rail is to be upgraded.

3. New crossties shall be handled to prevent any splitting or damaging of the crosstie. Any crosstie damaged shall be replaced by the CONTRACTOR at his expense.

4. The CONTRACTOR shall remove old crossties and straighten all remaining crossties that are skewed.

5. New crossties are to be installed in such a manner that crosstie and tie plates may be set in place without the use of track jacks.

6. Crossties shall be equally spaced between adjacent crossties and at right angles to the rail.

7. Surfaces of crossties and tie plates are to be clean before spiking up.

8. Tie plate installation, spiking and anchoring shall be in accordance with subsection TW-4.

9. All crossties are to be fully nipped.

10. All anchors and any anchors dislodged by the CONTRACTOR's operation shall be replaced.

11. All crossties installed shall be hand tamped in order to maintain adequate surface until the final tamping and surfacing operation.

G. Ballasting, surfacing and alignment shall be in accordance with subsection TW-4.

TW-12 Track Lining and Relocation

A. The CONTRACTOR shall line and/or relocate tracks as shown on the plans.

B. The CONTRACTOR shall exercise extreme caution during such operations to insure against damage to rail, crossties, or track material. All materials lost or damaged due to the CONTRACTOR's negligence shall be replaced with materials of acceptable quality at the CONTRACTOR's expense.

C. Relocation of tracks shall not disturb the subballast.

D. Track to be relocated shall be either paneled into units of one rail length and relocated to its new location or dismantled and rebuilt in its new location in accordance with subsection TW-4.

E. Track to be lined shall be lined with a backhoe, front end loader, dozer, or other equipment approved by the ENGINEER, and in such a manner as not to cause damage to the track structure.

F. The COMPANY may elect to change out bad crossties in tracks to be relocated or lined. The CONTRACTOR shall install crossties, furnished by the COMPANY, as directed by the ENGINEER and in accordance with subsection TW-4.

G. Ballasting, surfacing and alignment shall be in accordance with subsection TW-4.

TW-13 Turnout Relocation

A. The CONTRACTOR shall relocate turnouts as shown on the plans, except main line turnouts which shall be removed by COMPANY forces.

B. Turnouts shall not be installed until the roadbed subgrade has been finished and the subballast placed and compacted. Installation of turnouts shall be in accordance with subsection TW-8.

C. The CONTRACTOR shall exercise extreme caution during such operations to insure against damage to rail, switchties, or turnout material. All materials lost or damaged due to the CONTRACTOR's negligence shall be replaced with materials of acceptable quality at the CONTRACTOR's expense.

D. The COMPANY may elect to change out bad switchties in turnouts to be relocated. The ENGINEER shall designate switchties to be replaced by the CONTRACTOR. Replacement shall be in accordance with subsection TW-10.

E. Ballasting, surfacing and alignment shall be in accordance with subsection TW-4.

TW-14 Sale and/or Removal of Track and Turnouts

A. The CONTRACTOR shall purchase and/or remove track and/or turnouts as shown on the plans and directed on the bid sheet.

B. Tracks to be sold and removed shall include the “as-is, where is” sale of indicated tracks and the removal and disposal of those tracks.

C. Track sale and/or removal shall include removing spikes, joint bars, rail anchors, rails, tie plates, crossties, other track material and disposition of materials.

D. Turnout removal shall include disassembling turnout components and disposition of materials.

E. Disposition of materials not sold to the CONTRACTOR shall be in accordance with subsection TW-15.

F. The CONTRACTOR shall be responsible for shaping, smoothing and compacting the roadbed after removal of track or turnouts. Roadbed shall be free of ruts and depressions and shaped to allow for proper drainage.

TW-15 Disposition of Track and Turnout Materials Removed

A. The ownership of all track and turnout materials removed by the CONTRACTOR shall remain with the COMPANY, unless the bid sheet indicates the sale of track materials to the CONTRACTOR.

B. The CONTRACTOR shall handle track materials to be retained by the COMPANY in accordance with the following:

1. The CONTRACTOR shall sort and stockpile removed materials at locations designated by the ENGINEER.

2. Materials shall be loaded into COMPANY rail cars by the CONTRACTOR or, if applicable, used in track construction.

3. Jointed rail shall be stacked with the heads up and with sufficient support under the base.

4. Removed strands of welded rail shall be placed along the track roadbed, clear of interference with other project related operations, and any walkway of a live track.

5. Reusable crossties, as designated by the ENGINEER, shall be stacked and banded with metal straps in bundles of 16 or less.

6. The CONTRACTOR shall dispose of rejected crossties off the COMPANY's right of way unless otherwise directed by the ENGINEER. Disposal shall be in accordance with all local, state and federal laws.

7. Care shall be taken to prevent damage to salvaged materials during handling.

TW-16 Measurement and Payment

A. Measurement for payment shall be made by the Engineer.

B. Contract unit bid prices shall constitute full compensation for all labor, equipment, tools and incidentals necessary to complete the Work.

C. Payment for continuous welded rail or jointed rail track construction will be made at the Contract unit bid price per track foot of track constructed as measured along the track centerline by the Engineer. Track on long ties in turnouts will be excluded. Trackwork with steel ties will be differentiated between insulated and non-insulated trackwork.

D. Payment for thermal adjustment of rail shall be paid at the Contract unit bid price per track foot adjusted.

E. Payment for panel track construction will be made at the Contract unit bid price per track foot of panel track constructed as measured along the track centerline.

F. Payment for crane track construction will be made at the Contract unit bid price per track foot of crane track constructed as measured along one crane rail.

G. Payment for cutting crossties, furnished by the Company, required for crane track construction will be made at the Contract unit bid price per each crosstie cut.

H. Payment for panel turnout installation will be made at the appropriate Contract unit bid price for each panel turnout installed as measured.

I. Payment for turnout construction and installation will be made at the appropriate Contract unit bid price for each turnout constructed and installed.

J. Payment for derail construction and installation will be made at the appropriate Contract unit bid price for each derail constructed and installed.

K. Payment for switchtie installation will be made at the Contract unit bid price for each switchtie installed.

L. Payment for rail installation will be made at the appropriate Contract unit bid price per track foot installed as measured along the track centerline.

M. Payment for crosstie installation will be made at the Contract unit bid price for each crosstie installed.

N. Payment for surfacing existing track will be made at the Contract unit bid price per track foot of existing track surfaced as measured along the track centerline.

O. Payment for lining or relocating track will be made at the appropriate Contract unit bid price per linear foot of track lined or relocated as measured along the track centerline.

P. Payment for relocating turnouts will be made at the appropriate Contract unit bid price for each turnout relocated.

Q. Payment for the sale and/or removal of track will be made at the Contract unit bid price per track foot of track removed as measured along the track centerline. Track on long ties in turnouts will be excluded.

R. Payment for the sale and/or removal of turnouts will be made at the Contract unit bid price for each turnout removed.

S. The CONTRACTOR shall indicate the value of salvaged track materials credited to the project on the bid sheet.

T. The cost for unloading, moving, hauling distributing and stockpiling materials furnished by the Company will not be considered as a separate bid item, but shall be included in the appropriate bid items for the work performed.

U. All costs for unloading, distributing and transferring ballast and surfacing, including tamping, aligning and dressing of track and turnouts shall be included in the appropriate bid items for the work performed. There will be no separate payment for such work.

V. No separate payment will be made for building-up rail ends, unless provided for on the bid sheet.

W. No separate payment will be made for sawing and drilling rail ends, unless provided for on the bid sheet.

END OF SECTION

Division V: Barriers

Section GP – Guard Post

Section HG – Highway Guardrail

Section JB – Precast Jersey Barriers

Section RF – Right-of-Way Fence

Section SF – Security Fence

Section GP – Guard Post (Bollard)

GP-1 Description

The Work shall consist of furnishing all materials and installing concrete filled steel pipe guard post(s) in accordance with these Specifications and as shown on the plans or as directed by the ENGINEER.

GP-2 Material

A. Post shall be constructed of ASTM Schedule No. 40, Grade A, black steel pipe. Length and diameter of post shall be as shown on the plans.

B. Concrete shall have a minimum 28 day compressive strength of 3,000 psi and conform to the requirements of Section CS - Structural Concrete of these Specifications.

C. Paint

1. Prime coat shall be a gray organic zinc-rich epoxy primer.

2. Top coat shall be OSHA Safety Yellow latex.

GP-3 Installation

A. The CONTRACTOR shall locate guard post as shown on the plans. The ENGINEER shall approve post location prior to installation.

B. Post shall be set plumb in hole. Post hole shall be free of loose soil and rock or other debris and shall not contain water. Post hole shall be filled with concrete which shall be allowed to set before post is filled with concrete. Concrete shall be crowned 1 inch above finished grade to allow for water to drain away from the post.

C. Post shall be filled with concrete crowned 2 inches at the top.

D. Painting

1. Surface preparation

a. Exposed surfaces shall be cleaned of all grease, oil, mill scale, dirt, concrete, rust, old paint, or any other contaminants.

2. Application

a. Prime coat shall be applied at 3.0-4.0 mils Dry Film Thickness.

b. Two top coats shall be applied each at 1.5 mils Dry Film Thickness. A minimum of 24 hours shall be allowed between coats for the preceding coat to dry completely.

c. Application shall be by brush or spraying. Adjacent surfaces shall be protected. The CONTRACTOR shall be responsible for damage for overspray and airborne paint particles.

d. Paint shall not be applied when the air temperature in the shade is below 40° F or when the surface is wet. Paint shall not be applied when inclement weather conditions are pending. The CONTRACTOR shall repaint the post if weather affects drying.

GP-4 Measurement and Payment

A. Guard posts shall be measured by the number of each guard post installed.

B. Payment will be made at the contract unit price per each guard post installed, which price shall include all necessary material, labor and equipment. Payment shall include excavation, concrete foundation, filling post with concrete and painting.

END OF SECTION

Section HG – Highway Guardrail

HG-1 Description

A. The Work shall consist of the construction or relocation of highway guardrail in accordance with these Specifications and in conformity with the lines and grades shown on the plans or as established by the ENGINEER.

B. The construction of the guardrail shall include the furnishing, assembling and erecting of all component parts and materials.

C. The relocation of the guardrail shall include dismantling, cleaning, reshaping, repairing, storing and resetting.

HG-2 Material

A. Guardrail beams shall meet the following requirements unless otherwise specified.

1. Galvanized steel w-beams conforming to AASHTO M 180 for Class A, Type 1 guardrail.

2. Beams shall be furnished in standard lengths of 12 feet 6 inches or 25 feet.

3. Flared, buffer or end sections shall be of the same thickness of metal and the same type as the beam to which it is attached.

B. Posts and blockouts shall meet the following requirements unless otherwise specified:

1. Steel posts and blockouts shall be W 6x8.5 or W 6x9.

2. Steel posts shall conform to ASTM A 36.

3. Steel posts and blockouts shall be fully galvanized in accordance with AASHTO M 111.

4. Timber posts and blockouts shall be 8 inches x 8 inches and shall conform to AASHTO M 168. The species and grade of timber shall be Southern Yellow Pine, No. 1 Dense SR (1550 Fb, min.) or Douglas Fir, No. 1 Dense SR (1400 Fb, min).

5. All timber shall be fully creosoted in accordance with AASHTO M 133. Timber posts and blockouts shall be fabricated and holes drilled prior to treatment. Where modifications are required after treatment, preservative shall be added to new surfaces.

6. Composite blockouts shall be 8 inches x 8 inches and shall conform to AASHTO M 168.

7. Holes drilled in timber shall be slightly smaller than the designated bolt outer thread diameter.

8. All posts shall be a minimum of 5 feet 9 inches in length. Post length may be modifed by project plan when installation is to be used for other than automobiles and light trucks.

9. The use of more than 1 type of post or blockout material shall not be allowed.

C. Hardware shall meet the following requirements unless otherwise specified:

1. All metal hardware shall be in accordance with State Highway Department specifications or as shown on the plans.

2. All metal hardware shall be fully galvanized in accordance with AASHTO M 111.

D. Concrete shall have a minimum 28 day compressive strength of 3,000 psi and conform to the requirements of Section SC - Structural Concrete of these Specifications.

HG-3 Installation

A. Posts shall be set plumb in holes, or driven on a true line and grade at 6 feet 3 inches center to center.

B. The manner of driving shall be such as to prevent battering or distorting of posts.

C. Post holes shall have a diameter of 1 foot 6 inches and a minimum depth of 3 feet 6 inches. Post holes shall be free of loose soil and rock or other debris and shall not contain water.

D. Post holes shall be backfilled with concrete. Concrete shall be crowned 1 inch above finished grade to allow water to drain away from post.

E. Rail elements shall be erected in a manner resulting in a smooth, continuous installation conforming to established line and grade.

F. Height to top of beam from groundline shall be 2 feet 3 inches to 2 feet 4 inches. This height may be modifed by project plan when installation is to be used for other than automobiles and light trucks.

G. Shop-curved rail shall be used on curves with radii of 125 feet or less.

H. Sections of installed guardrail shall be terminated using flared, buffer or rounded end sections as shown on the plans.

I. Beams, posts and appurtenances for guardrail shall not be field punched, reamed or drilled to provide for lapped beams or for changes in location of splices necessitated by field clearances, except as may be approved by the ENGINEER after CONTRACTOR

has demonstrated that there will be no damage to the surrounding metal. No burning or welding shall be done in the field.

J. All bolts, such as expansion joint bolts, shall be drawn tight unless otherwise noted on plans. Bolts through expansion joints shall be drawn up as tight as possible without being tight enough to prevent the rail elements from sliding past one another longitudinally. Bolts shall be sufficiently long to extend at least 1/4 inch beyond the nuts. Splice bolts shall not extend more than 1/2 inch beyond the nuts. For double face guardrail, bolts through posts shall extend from 1/4 inch to one inch beyond the nuts.

HG-4 Highway Guardrail Relocation

A. Existing guardrail to be relocated shall be dismantled and reset at locations shown on the plans or as directed by the ENGINEER. The work shall include the furnishing of all necessary hardware and other appurtenances required to replace those that are not suitable for reuse.

B. Any required clearing and grubbing, demolition and grading shall be performed in accordance with the provisions of Sections CG - Clearing and Grubbing, DM - Demolition and GR - Grading, respectively, of these Specifications.

C. All posts shall be removed in such a manner as will not damage the posts for further use.

D. All materials which can be salvaged shall be dismantled, inventoried, cleaned, reshaped, repaired and stored until reset.

E. Any material not satisfactory for reuse, as determined by the ENGINEER, shall be disposed of off-site by the CONTRACTOR.

F. The CONTRACTOR shall replace, at his own expense, with material of the type and kind damaged or lost, any material lost or damaged on account of carelessness, negligence, or failure to properly protect the material.

G. Resetting shall be in accordance with subsection HG-3 of this Section except posts shall be spaced as originally spaced, unless otherwise shown on the plans.

HG-5 Measurement and Payment

A. Measurement

1. New highway guardrail shall be measured in place, from end to end excluding end treatments, by the number of linear feet of new highway guardrail installed.

2. New highway guardrail end treatments shall be measured per unit basis.

3. Relocated highway guardrail shall be measured in place, from end to end including end treatments, by the number of linear feet of highway guardrail relocated.

B. Payment

1. Payment for new highway guardrail will be made at the Contract unit bid price per linear foot of new highway guardrail installed, which price shall include all necessary material, labor and equipment.

2. Payment for new highway guardrail end treatments will be made at the Contract unit bid price per unit installed, which price shall include all necessary material, labor and equipment.

3. Payment for relocated highway guardrail will be made at the Contract unit bid price per linear foot of highway guardrail relocated, which price shall include all necessary material, labor and equipment. No separate payment will be made for additional bolts, etc. and other incidentals, including offsite disposal of unsalvageable materials required to complete the relocation of the highway guardrail. No separate payment shall be made to relocate end treatments.

4. Payment for clearing and grubbing will be made in accordance with Section CG - Clearing and Grubbing of these Specifications.

5. Payment for demolition will be made in accordance with Section DM - Demolition of these Specifications.

6. Payment for grading will be made in accordance with Section GR - Grading of these Specifications.

END OF SECTION

Section JB – Precast Jersey Barriers

JB-1 Description

Work shall consist of furnishing and placing precast jersey barriers in the locations specified on the project Plans.

JB-2 Instructions

A. Precast jersey barriers

1. Barriers shall be formed from 3,000 psi (min.) concrete.

2. Barriers shall be based on local DOT designs, but shall generally be between 10 and 12 feet in length and 2 feet in width at the base. Barriers shall be constructed with rebar and tie loops per local DOT designs.

B. Precast barriers shall be painted OSHA Safety Yellow with a durable primer.

C. Barriers shall be handled with care, and shall be free from defections after installation.

JB-3 Measurement and Payment

A. Payment for new jersey barriers shall be made at the Contract price per each jersey barrier. Payment shall include painting and transportation.

B. Payment for painting and/or relocating existing jersey barriers shall be made at the Contract price per each existing jersey barrier painted and/or relocated.

END OF SECTION

Section RF – Right-of-Way Fence

RF-1 Description

The Work shall consist of furnishing and installing a steel woven wire fence as shown on the plans or as directed by the ENGINEER.

Unless noted on the plans, fence shall consist of steel woven wire fence fabric with one strand of barbed wire on top.

RF-2 Material

A. Steel woven wire fence fabric shall meet the following requirements unless otherwise specified:

1. Fabric shall conform to the requirements of ASTM A 116, Grade 60, with wire gage and spacing as shown on the plans.

2. Fabric shall have a Class 3 weight of zinc coating.

3. Unless otherwise specified, packaging, marking and loading shall be in accordance with the requirements of ASTM A 700.

B. Barbed wire shall meet the following requirements unless otherwise specified:

1. Barbed wire shall be zinc-coated steel wire consisting of a strand of two 12-1/2 gage wires with 4 points 12-1/2 gage barbs on 5 inch centers and conform to the requirements of ASTM A 121.

2. The minimum weight of zinc coating shall be 0.80 ounces per square foot (oz./sq.ft.) (Class 1).

C. Brace wire shall be No. 7 or No. 9 gage galvanized steel wire as shown on the plans.

D. Staples shall be No. 9 gage galvanized steel strand wire and shall not be less than 1 inch long.

E. Wood posts shall meet the following requirements unless otherwise specified:

1. Posts shall be treated Southern Pine or untreated Black Locust as defined in AASHTO M 168.

2. Southern Pine shall be treated in accordance with the requirements of AASHTO M 133 and AWPA (American Wood Preservers Association) C5 with creosote meeting the requirements of AWPA P1, pentachlorophenol meeting the requirements of AWPA P8 in a hydrocarbon solvent meeting the requirements of AWPA P9, Type A, or ammoniacal copper arsenate or chromated copper arsenate meeting the requirements of AWPA P5.

3. Posts treated with Pentachlorophenol shall not be used where they will come in contact with salt water.

4. Where creosote is used, there shall be a minimum retention of 10 pounds per cubic foot of wood.

5. All posts shall be of the dimensions as shown on the plans. All thickness dimensions shall be undressed unless otherwise specified and shall not vary from the specified dimensions by more than 1/4 inch.

F. Steel line posts shall meet the following requirements:

1. Posts shall conform to the requirements of ASTM A 702.

2. Posts shall be a T section type fabricated from Steel B and have a Steel B anchor plate.

3. Finish shall be galvanized.

4. Length of posts shall be as shown on the plans.

5. Wire fasteners shall be studs so placed as to engage a substantial number of fence line wires in proper positions.

6. Fasteners shall be formed from zinc-coated steel wire not less than 0.120 inch diameter zinc-coated in accordance with the requirements of ASTM A 641. Weight of coating shall be Class 1.

7. Post assemblies for bracing shall conform to the requirements of ASTM A 702.

8. Unless otherwise specified, packaging, marking and loading shall be in accordance with the requirements of ASTM A 700.

G. Gates shall be of the type and width as shown on the plans.

H. Concrete shall have a minimum 28 day compressive strength of 3,000 psi and conform to the requirements of Section SC - Structural Concrete of these Specifications.

RF-3 Installation

A. The CONTRACTOR shall clear all vegetation required to install the fence.

B. Fence shall be installed on true alignment and grade. Fence post tops shall form a regular grade line.

C. Posts, with the exception of brace posts, shall be spaced equidistant at intervals as shown on the plans with interval being measured parallel to the grade of the fence and in the line of fence from center to center of posts.

D. Brace posts shall be spaced on each side of all corner, pull and gate posts as shown on the plans.

E. Wood posts shall be set in holes of diameter as follows:

   1. Line posts – 12-inch diameter (at top)

   2. Terminal posts – 18-inch diameter (at top)

      a. Includes end, corner, pull, bracing, and gate posts.

F. The depth of hole for a terminal post (including end, corner, pull, bracing and gate) shall be 2 inches deeper than the post embedment as shown on the plans. The depth of the hole for a line post shall be the same as the post embedment as shown on the plans.

G. Wood posts shall be set in vertical position, large end down, plumb and in line.

H. Terminal (end, corner, pull, bracing and gate) posts shall be backfilled with concrete. Concrete shall extend 2 inches above grade and crowned to shed water. Posts shall be set in concrete 3 days before any fabric is installed.

I. All other wood posts shall be backfilled with suitable and available material as directed by the ENGINEER. The backfill shall be thoroughly compacted in approximately 6 inch layers.

J. Steel posts shall be driven, plumb and in line or otherwise installed in a manner approved by the ENGINEER.

K. Posts which are broken, bent or otherwise damaged to the extent their serviceability or appearance is significantly affected, shall be replaced at no cost to the COMPANY.

L. Anchors and bracing shall be provided at ends, corner, gates and at intermediate post locations where the vertical or horizontal alignment of the fence changes 15° or more, but not to exceed 500 feet.

M. Fabric shall be stretched taut and securely fastened to each post. Splicing shall be permitted only at the posts, unless a splice is provided which develops a strength comparable to the strength of the fabric. Each horizontal strand of wire shall be wrapped around the end of gate post and securely fastened by winding it around the wire leading to the gate post. When wood posts are used, the top and bottom strands and at least 3 horizontal strands of fabric shall be securely fastened to each post with galvanized wire staples. When metal posts are used, the top and bottom strands and at least 3 horizontal strands of fabric shall be securely fastened to each post with galvanized wire clamps or other approved methods. The bottom of the fabric shall not be more than 3 inches to 4 inches above ground line at any point.

N. Barbed wire shall be pulled taut and fastened to wood posts with galvanized wire staples and to metal posts with galvanized wire clamps or other approved methods.

O. Terminal (end, corner, pull, bracing and gate) posts shall be braced with galvanized wire to be placed around posts with one wire on each side of brace. Wires shall be drawn taut by twisting between the brace and each post. This applies to all wires.

P. At end or corner posts, horizontal wood braces, 4-5 inch diameter, shall be placed between the end or corner post and adjacent brace posts as shown on the plans. Braces shall be placed 6 inches below the top of the posts. They shall be held in place by 3/4 inch galvanized dowels at each end.

Q. Gate operation shall be smooth and even. Gates shall match when locked. If location of gate(s) is not shown on the plans, they shall be erected at a location designated by the ENGINEER.

RF-4 Measurement and Payment

A. Measurement

1. Right of way fence shall be measured in place by the number of linear feet of right of way fence installed.

2. Gates shall be measured per each type of gate installed.

B. Payment

1. Payment for right of way fence will be made at the Contract unit price per linear foot of right of way fence installed, which price shall include all necessary material, labor and equipment. No separate payment shall be made for any clearing that is required for installation of the fence.

2. Payment for gates including water gates, will be made at the Contract unit price per each type of gate installed, which price shall include all necessary material, labor and equipment.

END OF SECTION

Section SF – Security Fence

SF-1 Description

The Work shall consist of furnishing and installing steel chain-link security fence as shown on the plans or as directed by the ENGINEER.

Unless noted otherwise on the plans, fence will consist of a 96-inch tall woven wire fabric with an additional 12 inches of barbed wire (3 strands). If identified by plans, a barbed tape obstacle may be utilized.

CONTRACTOR shall also furnish and install gates as called for on the plans.

SF-2 Material

A. Fabric shall meet the following requirements unless otherwise specified:

1. Fabric shall be zinc-coated steel and conform to the requirements of ASTM A392.

2. Fabric shall be zinc-coated after weaving, with the weight of zinc coating being 2 ounces per square foot (oz./sq. ft.) (ASTM A392 Class 2).

3. Height of fabric shall be 96 inches.

4. Mesh size shall be 2 inches.

5. Diamond count shall be 24-1/2.

6. Wire constituting the fabric shall be No. 9 gage (0.148 inches) and have a minimum breaking strength of 1290 pounds.

7. Fabric shall have twisted and barbed selvages at both top and bottom.

8. Each length of fabric shall be tightly rolled and firmly tied. Each roll shall carry a tag showing the class of coating, the specified wire size, the mesh size, the specified length and height of fabric in the roll, ASTM Designation A 392 and the name or mark of the manufacturer. Unless otherwise specified, packaging, marking and loading for shipment shall be in accordance with the requirements of ASTM A 700.

B. Posts, top rail and braces shall meet the following requirements:

1. Fence tubing shall be cold-formed, electric-welded, and conform to the requirements of ASTM F1043, Group 1A for heavy industrial chain-link fence applications.

2. Tubing shall meet or exceed the strength requirements of Schedule 40 steel pipe.

3. Internal surfaces shall have a zinc-rich coating applied capable of providing galvanic protection. The zince coating shall contain at lead 90% zinc powder by weight.

4. External surfaces shall be triple-coated with a zinc initial coating, chromate middle coating, and polyurethane acrylic outer coating. The zinc initial coating shall be 1.0 oz. per square foot (+/- 0.1 oz. per square foot). The chromate coating shall be 30 micrograms per square inch (+/- 15 micrograms per square inch). The polyurethane coating shall be 0.5 mils (+/- 0.2 mills).

5. All coatings shall be applied inside and out after welding.

6. Pipe shall be straight, true to section and conform to the following weights. Pipe shall be Type I unless otherwise noted on plans.

Nominal Pipe Size (in):	Pipe Sizes		Weight (lbs./ft)	Wall Thickness (in.):
	I.D. (in.):	O.D. (in.):		
1 5/8	1 1/4	1 5/8	1.84	0.111
2	1 1/2	2	2.28	0.120
2 1/2	2	2 1/2	3.12	0.130
3	2 1/2	3	4.64	0.160
3 1/2	3	3 1/2	5.71	0.160
4	3 1/2	4	6.56	0.160
6*	6	6 5/8	18.97	0.28
8*	8	8 5/8	28.55	0.322

** Use Schedule 40 steel pipe for fence posts larger than 4".*

7. Unless otherwise noted on plans, pipe outside diameters (O.D.) for posts, top rails and braces shall be as follows:

   a. Top rail and braces: 1-5/8”

   b. Line Posts: 2-1/2”

   c. Terminal posts (end/corner/pull): 3”

   d. Gates (panel width < 6 ft): 3”

   e. Gates (panel width 6 ft - 12 ft): 3-1/2”

   f. Gates (panel width 13 ft – 18 ft): 6” (Use Schedule 40 steel pipe)

   g. Gates (panel width > 18 ft): 8” (Use Schedule 40 steel pipe)

8. Top rail shall be furnished in minimum lengths of 18 ft.

C. Fence fittings shall meet the following requirements unless otherwise specified:

1. Fittings shall be zinc-coated and conform to the requirements of ASTM F 626.

2. Tension bars, steel strip, 1/4 inch in thickness and 3/4 inch in width, shall be used to connect the fabric to end, gate and corner posts.

3. Tension bands, pressed steel, No. 11 gage in thickness and 3/4 inch in width, shall be spaced at a maximum of 12 inch intervals.

4. Wire ties and clips for fastening fabric to top rail, posts, or tension wire shall be No. 9 gage galvanized steel wire with a minimum weight of zinc coating of 1.80 oz./sq. ft. (Class B Coating) of uncoated wire surface with a tensile strength of 65,000 p.s.i.

5. Tension wire shall be No. 7 gage zinc-coated steel coil spring wire and have a breaking strength of 1,950 pounds minimum and 3,200 pounds maximum.

6. Truss rods shall be steel rod, 3/8 inch merchant quality with turnbuckle.

7. Post caps shall be pressed steel, malleable iron or cast aluminum alloy designed to fit snugly over posts to exclude moisture. Supply cone type caps for terminal posts (including end, corner, gate and pull) and loop type for line posts.

8. Brace bands shall be pressed steel, 12 gage in thickness and 3/4 inch in width.

9. Hog rings shall be No. 11 gage steel wire, with a minimum weight of zinc coating of 0.80 oz./sq. ft. of wire surface.

10. Barbed wire arms shall be pressed steel, cast iron, or cast aluminum alloy fitted with clips or slots for attaching three strands of barbed wire. Arms shall be set outward on a 45° angle and be capable of supporting a 250 pound load at outer barbed wire connecting point without causing permanent deflection.

11. Rail and brace ends shall be pressed steel , cast iron or cast aluminum alloy, cup-shaped to receive rail and brace ends.

12. Top rail sleeves shall be tubular steel, 0.051 inch in thickness and 7 inches in length, expansion type.

D. Barbed wire shall meet the following requirements unless otherwise specified:

1. Barbed wire shall be zinc-coated steel wire consisting of a strand of two 12-1/2 gage wires with 4 points 14 gage barbs on 5 inch centers and conform to the requirements of ASTM A 121.

2. The minimum weight of zinc-coating shall be 0.80 oz./sq. ft.

E. Barbed tape obstacle shall meet the following requirements unless otherwise specified:

1. Barbed tape obstacle shall be stainless steel, 0.025 inch in thickness and 1 inch in width, machined to produce clusters of 4 barbs on a minimum of 4 inch centers.

2. Barbs shall be needle sharp and a minimum of 1.2 inches in length as measured from the barb point to the center line of the barb cluster.

3. Barbed tape shall be permanently cold-clenched a minimum of 230° around a hot-dipped 0.098 inch diameter galvanized zinc steel coil wire and have a minimum tensile strength of 220,000 psi in accordance with ASTM A 764, Finish 2, Class II, Type 3.

4. Fifty-two (52) barbs or 13 groups of barbs per loop.

F. Swing gates shall meet the following requirements unless specified otherwise:

1. Frames shall be made from 2 inch O.D. Type I or Type II pipe with welded joints. Welded areas shall be repaired with zinc-rich coating applied per manufacturer's directions. Frames to be securely welded, braced and trussed to prevent sagging.

2. Frames shall conform to the requirements of ASTM F 900.

3. Frame shall be covered with fabric of same gage as used on the fence. Fabric shall be fastened on all four sides by means of adjustable hook bolts and tension bars.

4. Barbed wire shall be fastened to the extended end bars of gate frames.

5. Gates shall be complete with necessary fittings.

6. Gate accessories, hinges, latches, stops, keepers and necessary hardware shall be quality required for industrial and commercial applications.

7. Gate hinges shall be structurally capable of supporting the gate leaf and allow the gate to open and close without binding.

8. Latches shall permit padlocking with a 1/2 inch shank padlock.

9. Gate stops shall be installed as shown on the plans. Stops shall be suitable for setting in concrete for the center drop rod or plunger.

10. Gate keepers shall be provided as shown on the plans. Keepers shall consist of a mechanical device for securing the free end of the gate when in full open position. Keepers shall be set in concrete.

G. Sliding gates shall meet the following requirements unless specified otherwise:

1. Frames shall be made from 2 inch square aluminum alloy 6063 T-6 tubing, radius corner, and 0.125 inch wall thickness and weigh 1.04 pounds per linear foot.

2. Internal vertical members shall be made of 1-1/4 inch square aluminum alloy, 6063 T-6 tubing, 0.125 wall thickness. Members shall be spaced 8 feet on centers.

3. Each panel shall have a fixed diagonal brace. Brace shall be 1-1/4 inch square aluminum alloy 6063 T-6 tubing, 0.125 inch wall thickness.

4. Frames shall be welded so as to form a rigid one-piece unit.

5. Track shall be a one-piece aluminum extrusion alloy 6061 T-6 in accordance with the requirements of ASTM B 221, 2.86 inch O.D., with 5-1/4 inch wide frame flange, weight 6.63 pounds per foot and a 0.50 inch wall thickness.

6. Trucks shall be 7 inches in length and 1/2 inch in thickness manganese bronze body with 2 sets of ball type stainless steel rollers, turning on a heavy duty precision ground factory sealed lubricated roller bearings. Basic dynamic capacity of each bearing shall be 3,930 pounds.

7. Bottom guide shall be positioned at each support post with 3/8 inch stainless steel U-bolts. Guide body shall be cast aluminum with a 2 inch diameter by 3 inches in length nylon rollers that turn freely on a 5/8 inch diameter stainless steel stud.

8. All gate truck hangers, latches, brackets, guide assemblies, stops and other accessories shall be aluminum.

9. A positive latch shall be provided with provisions for 1/2 inch shank pad lock.

10. Cantilever overhang distance shall be as follows:

    a. 16-foot gate opening: 8 foot overhang (max.)

    b. 24-foot gate opening: 12 foot overhang (max.)

    c. 30-foot gate opening: 15 foot overhang (max.)

H. Motor for gates shown on the plans to be motorized shall meet the requirements shown on plans. Installation of gate motor systems shall includes the following work:

1. Work shall include electrical wiring, control wiring, and control equipment as shown on Plans. All work shall conform to manufacturer's instructions.

2. Motorized gates shall include overrides to allow for manual operation.

3. Motorized gates systems shall include safety sensors to prevent entrapment.

I. Crash gates shall meet the following requirements unless otherwise specified:

1. Crash gates shall be made of steel tubing having a minimum tensile strength of 36,000 p.s.i. (ASTM Grade A) and dimensions as shown the plans.

2. Tubing shall be sawcut.

3. All holes shall be drilled.

4. Crash gates shall be welded. Welds shall be made smooth and flush and shall be of A36 steel and in accordance with the AWS Welding Code.

5. Crash gates shall be painted OSHA Safety Yellow.

6. Holes for padlocks shall accommodate a 1/2 inch shank padlock.

J. Crash gates shall be painted as follows:

1. Prime coat - Gray organic zinc-rich epoxy primer.

2. Top coat - Safety yellow latex.

K. Concrete - Shall have a minimum strength of 3000 psi after 28 days.

SF-3 Installation

A. CONTRACTOR shall clear all vegetation required to install the fence.

B. Fence shall be installed on true alignment and grade as shown on the plans, with a maximum of one inch from the bottom of fabric to the ground line.

C. All posts shall be spaced equidistant at intervals not exceeding 10 feet. Interval shall be measured parallel to the grade of the fence and in the line of fence from center to center of post.

D. Terminal posts (end, corner, pull and gate) shall be set at the beginning and end of each continuous length of fence and at abrupt changes in vertical alignment and at any change in horizontal alignment. Pull posts shall be placed a maximum of 300 feet center to center of posts.

E. Posts shall be set in holes of diameter and depth as follows:

Post Type:	Hole Diameter (in.):	Hole Depth (in.):	Post Embedment (in):
Line Post	9	40	36
Terminal Post*	12	40	36
Gate Post	18	48	42

** Includes end, corner, and pull posts.*

F. Loose dirt from around post holes shall be removed and loose dirt in post holes shall be tamped prior to placing posts.

G. Posts shall be set in a vertical position, plumb and in line. Concrete shall be placed into the excavation and shall be crowned 1 inch above grade to shed water away from the post.

H. All posts shall be set in the concrete footing 3 days before any fabric is installed.

I. Terminal (end, corner, pull and gate) posts shall be braced. Braces shall be installed midway between the top of fabric and ground line, extending from the terminal post to the first line post. Braces shall be attached with malleable rail ends and brace bands securely trussed with truss rods from the line post back to the base of the terminal post.

J. Top rail shall be supported at each post by the post caps so that a continuous brace from end to end of each stretch of fence is formed. Top rail shall be securely fastened to the terminal posts and joined securely with sleeves or couplings to allow for expansion and contraction.

K. Bottom tension wire shall be placed 3 inches to 4 inches above the bottom of fence. Wire shall be pulled tight before attaching ends to terminal posts. Fasten to outside of line posts with wire ties. Tension wire shall be taut and free of sag.

L. Fabric shall have a smooth uniform appearance free from sag.

M. Fabric shall be cut by untwisting a picket and each span independently attached at all terminal posts. Tension bars with tension bands at maximum of 15 inches shall be used.

N. Fabric shall be fastened to line posts and to the top rail at intervals not exceeding 12 inches and bottom tension wire at intervals not exceeding 24 inches. Tie wires shall be twisted a full 360°. Both ends of tie wire shall be twisted. Tie wires shall fasten fabric at the diamond weave. Hog rings shall be used to fasten fabric at the diamond weave to the bottom tension wire. Bottom tension wire shall be fastened to posts with tie wires.

O. Rolls of fabric shall be joined by weaving a single picket into the ends of the rolls to form a continuous mesh.

P. Barbed wire shall be pulled taut to remove all sag, firmly installed in the slot of the 45° barbed wire arms and secured to a post or terminal arm.

Q. Barbed tape obstacle shall be 18 inches in diameter single coil on 18 inch centers per loop. The barrier shall be a continuous spiral attached to the fence at 18 inch intervals in position as shown on the plans or as directed by the ENGINEER. Attachment is with steel hog rings.

R. Where barbed obstacle is installed, CONTRACTOR shall furnish and install warning signs on fence spaced on 200 feet intervals and 5 feet above the bottom of the fence. Sign specifications and wording shall be as shown on the plans.

S. Gates shall be plumb, level and secure for full opening without interference. Top of gate shall be in line with top rail of the fence. Height of gate posts shall include extension for tying off 3 strands of barb wire. Gate operation shall be smooth and even. Gates must match when locked. If location of gate(s) is not shown on the plans, they shall be erected where directed by ENGINEER.

T. Operating controls for motorized gates shall be located as shown on the plans. CONTRACTOR shall furnish and install necessary wiring.

U. Fasteners (nuts for fittings, bands and hardware bolts) shall be installed on the inside of the fence.

V. Surfaces to be painted shall be prepared and paint applied as follows:

1. Exposed surfaces shall be clean of all grease, oil, mill scale, dirt, concrete, rust, old paint, or any other contaminants.

2. Prime coat shall be applied at 3.0 - 4.0 mils Dry Film Thickness.

3. Two top coats shall be applied each at 1.5 mils Dry Film Thickness. A minimum of 24 hours shall be allowed between coats for the preceding coat to dry completely.

4. Application shall be by brush or spraying. Adjacent surfaces shall be protected. CONTRACTOR shall be responsible for damage for overspray and airborne paint particles.

5. Paint shall not be applied when the air temperature in the shade is below 40□F or when the surface is wet. Paint shall not be applied when inclement weather conditions are pending. CONTRACTOR shall repaint if weather affects drying.

W. The area of installation shall be left free of debris caused by the installation of the fence.

SF-4 Measurement and Payment

A. Measurement

1. Security fence with barbed wire shall be measured in place by the number of linear feet of security fence with barbed wire installed.

2. Barbed tape obstacle shall be measured in place by the number of linear feet of fence where barbed tape obstacle is installed.

3. Gates shall be measured per each type (motorized, swing, crash) gate installed.

B. Payment

1. Payment for security fence with barb wire will be made at the Contract unit bid price per linear foot of security fence with barbed wire installed, which price shall include all necessary material, labor and equipment. No separate payment shall be for clearing required for installation of the fence.

2. Payment for barbed tape obstacle will be made at the Contract unit bid price per linear foot of security fence where barbed tape obstacle is installed, which price shall include all necessary material, labor and equipment.

3. Payment for gates will be made at the Contract unit bid price per each type of (motorized, swing, crash) and size of gate installed, which price shall include all necessary material, labor and equipment.

END OF SECTION

Division VI: Structures

Section MF – Metal Fabrication

Section PS – Pre-Engineered Metal Structures

Section SC – Structural Concrete

Section MF – Metal Fabrication

MF-1 Description

Work includes fabrication and installation of small metal structures, including camera bridges, crash gates, height restrictors, metal stairs, and handrails.

MF-2 General

A. See section PS – Pre-Engineered Metal Structures for specifications regarding metal buildings.

B. Prior to fabrication, CONTRACTOR shall submit the following for approval by the ENGINEER:

1. Shop drawings indicating materials, sizes, connections, anchors, and painting.

2. Product data, including manufacturer's catalog sheets on pre-manufactured items.

C. Steel welding requirements

1. Conform to codes for arc and gas welding in building construction of AWS and to AISC Specifications. Surfaces to be welded shall be free from loose scale, rust, grease, paint, and other foreign material, except mill scale which will withstand vigorous wire brushing may remain. No welding shall be done when base metal temperature is lower than 0°F.

2. Qualify welding operators in accordance with AWS D1.1. Qualification tests shall be run by recognized testing laboratory approved by ENGINEER at CONTRACTOR'S expense.

3. Welding operators shall be subject to examination for requalification using equipment, materials, and electrodes employed in execution of Work. Such requalification, if ordered by ENGINEER, shall be done at CONTRACTOR'S expense

D. Aluminum welding requirements:

1. Weld with gas metal arc (GMA) or gas tungsten arc (GTA) processes in accordance with manufacturer's recommendations as approved and in accordance with recommendations of AWS.

E. Delivery, Storage, and Handling

1. Tag miscellaneous aluminum, including anchor bolts, concrete anchors, sleeve, and bases, or otherwise mark for ease of identification at project site.

2. CONTRACTOR is responsible for safely transporting and handling all materials. All materials shall be protected from damage during all phases of construction.

MF-3 Material

A. Structural steel:

1. W Shapes: ASTM A992, 50 ksi
2. L Shapes: ASTM A36
3. Plates and Bars: ASTM A36
4. Tubing:
   a. Cold-drawn tubing shall be ASTM A512, sunk drawn, butt welded, cold finished, and stress relieved.
   b. Hot-formed tubing shall be ASTM A501, butt welded, cold finished, and stress relieved.
5. Pipe: ASTM A 53, Type E or S, grade A Schedule 40
6. Sheets: ASTM A 53, Type E or S, grade A Schedule 40

B. Stainless steel:

1. Exterior and submerged uses: AISI, Type 316
2. Cast-in-Place Anchor Bolts: AISI, Types 302, 303, or 304

C. Aluminum structural shapes and plates shall be alloy 6061-T6 or 6063-T6.

D. Connections for steel members shall comply with ASTM A325.

E. Anchor bolts shall conform to ASTM A307 with ½ inch minimum diameter. Non-submerged anchor bolts shall be galvanized, and anchor bolts submerged below water or finished grade shall be stainless steel.

F. Connection bolts for aluminum structures shall be constructed of stainless steel.

G. Shop primer shall be an alkyd enamel finish paint applied in a uniform dry film not less than 1-1/2 mils thick.

H. Welding electrodes shall be low-hydrogen type conforming to AWS D1.4.

I. Fasteners shall be galvanized steel fasteners of the type, grade, and class required for the installation of miscellaneous structures unless otherwise noted on the Plans.

MF-4 Fabrication

A. Connections and workmanship:

1. Fabricate details and connection assemblies in accordance with Drawings and Specifications, with projecting corners clipped and filler pieces welded flush.

2. Weld shop connections and bolt or weld field connections, unless otherwise noted or specified.

3. Provide clips, lugs, brackets, straps, plates, bolts, nuts, washers, and similar items, as required for fabrication and erection.

4. Use connections of type and design required by forces to be resisted and to provide secure fastening.

    a. AISC standard 2-angle web connections or single plate framing connections capable of supporting minimum of 50% total uniform load capacity of members joined as tabulated in uniform load constants of AISC M016.

    b. Connections shall consist of minimum of two 3/4 in. dia bolts or welds developing minimum of 10,000 lbs.

    c. Make bearing type bolted connections with minimum 3/4 in. dia bolts with threads included in shear plane, unless detailed otherwise.

5. Welding:

    a. Grind exposed edges of welds to 1/8 in. minimum radius. Grind burrs, jagged edges, and surface defects smooth.

    b. Prepare welds and adjacent areas so there is:

        i. No undercutting or reverse ridges on weld bead.

        ii. No weld spatter on or adjacent to weld or other area to be painted or coated.

        iii. No sharp peaks or ridges along weld bead.

    c. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.

6. Bolting:

    a. Draw up bolts or nuts tight in accordance with AISC specifications. Use bolts of lengths required so bolts do not project more than 1/4 in. beyond face of nut. Do not use washers unless specified. Provide hexagonal head bolts with hexagonal nuts.

b. Provide holes required for connection of adjacent or adjoining Work wherever noted on Drawings. Locate holes for bolting equipment to supports to tolerance of +/- 1/16 in. of dimensions indicated.

7. Fit Work together in fabrication shop and deliver complete or in parts, ready to be set in-place or assembled in field.

8. Galvanizing:

   a. Galvanize after fabrication.

   b. Galvanize by hot-dip process conforming with ASTM A123 and American Hot-Dipped Galvanizers Association specifications.

   c. Galvanize in plant having facilities to produce quality coatings and capacity for volume of Work.

   d. Ship and handle in manner to avoid damage to zinc coating

9. Painting or Coating and Finishes:

   a. Paint aluminum in contact with concrete and dissimilar material with 2 coats of epoxy paint.

   b. Under no circumstances shall aluminum contact dissimilar metal.

10. Castings shall be of uniform quality, free from blowholes, porosity, hard spots, shrinkage distortion, smooth, and well cleaned by shot blastings.

B. Anchoring

1. Epoxy adhesive anchors may be used with Type 316 stainless steel studs or anchor rod assembly, nuts, and washers.

2. Concrete expansion anchors shall be constructed of stainless steel.

MF-5 Installation

A. Foundation work:

1. Layout and install connectors, including concrete anchors and anchor bolts, to secure metal fabrications to concrete foundations.

2. Metal posts embedded in concrete shall be installed so that no part of the metal structure comes into contact with soil. Minimum cover for embedded posts shall be 4 inches or as shown on Plans.

3. Concrete anchors:

    a. Drill holes in concrete work with rotary driven twist drills only.

    b. Do not install until concrete has reached specified minimum strength (f'c).

    c. Do not install closer than 6-bolt dia. to edge of concrete, or closer than 12-bolt diameter to another anchor unless detailed on Drawings.

    d. Minimum embedment shall be 8-bolt dia.

    e. Locate to clear reinforcing bars in concrete.

    f. Install in accordance with manufacturer's recommendations.

B. Erect to lines and levels, plumb and true, and in the orientation shown on the Plans. Secure parts using concealed connections whenever possible.

C. Plumb and true vertical and horizontal members to tolerance of +/- 1/8 in. in 10 ft.

D. Provide bolts, shims, blocks, nuts, washers, wedges, and other items to complete installation.

E. Drill field holes for bolts. Do not burn holes.

F. New or enlarging holes by use of cutting torch is cause for rejection of entire member.

G. Perform cutting, drilling, and fitting required for installation of metal fabrications.

H. Field repair of galvanized coatings:

1. Repair galvanized surfaces damaged during shipping or erection/construction operations.

2. Repair surfaces using zinc-rich paint.

3. Prepare surfaces and apply in accordance with ASTM A780, Annex A2.

MF-6 Measurement and Payment

A. Measurement

1. Metal structures shall be measured per each type of structure fabricated and installed.

2. Linear structures, including handrails, shall be measured per linear foot when bid separately from another structure. Handrails constructed as part of a prefabricated stair, reload dock, or building shall be included in the unit measurement for the overall structure.

B. Payment

1. Payment for metal structures will be made at the Contract unit price per each structure fabricated and installed. Price shall include all necessary material, labor, equipment, fabrication, erection, and concrete foundations.

2. Payment for linear structures, including handrails, shall be paid at the Contract unit price per linear foot when bid separately from a structure. Price shall include all necessary materials, labor, equipment, erection, and foundation/anchoring work.

END OF SECTION

Section PS – Pre-Engineered Metal Structures

PS-1 Description

This work shall consist of the design and installation of a pre-engineered metal building as shown on the applicable project plans. The work includes all labor, materials, equipment, transport, design, permitting, and other work required.

PS-2 General Requirements

A. Reference Standards

1. CONTRACTOR and Manufacturer shall abide by all applicable local, state, or national building codes, laws, regulations, and safety standards.

2. At minimum, the CONTRACTOR and Manufacturer shall abide by the following codes, specifications, standards, and recommended practices. In case of conflict, the most restrictive standards apply.

    a. American Society for Testing and Materials (ASTM)

    b. American Institute of Steel Construction (AISC) – see current Specifications for Structural Steel Buildings

    c. American National Standards Institute (ANSI)

    d. American Welding Society (AWS), including Standard Welding Symbology (AWS A-2.4), Structural Welding Code - Steel (AWS D-1.1), and Structural Welding Code – Sheet Steel (AWS D-1.3).

    e. MBMA Low Rise Building Systems Manual – current edition

    f. National Electric Code (NEC) and applicable local electric code

    g. Applicable Federal, State, and local building code

    h. Underwriters Laboratory - UL 580

    i. AISI – Specification for the Design of Cold-Formed Steel Structural Members

    j. Steel Structures Painting Council (SSPC) – Surface Preparation Specification No. 2 (SSPC-SP2)

B. Quality Assurance:

1. Design all systems according to professionally recognized methods and standards and legally adopted codes or regulations.

2. Metal building Manufacturer shall be a member of the Metal Building Manufacturer's Association (MBMA).

3. Metal building Manufacturer shall be certified in accordance with American Institute of Steel Construction (AISC) quality certification program category MB for metal buildings. This certification shall cover areas of general management, engineering, procurement, and quality control. The Manufacturer shall provide proof of certification upon request.

4. Supplier/Manufacturer must be a primary manufacturer of frames, secondary steel, roof, and wall sheeting and trim.

5. Steel erectors shall have a minimum of 5 years experience in steel erection and be licensed in that profession as required by local, state, or federal laws. Upon request, erector shall provide references of five similar installation projects completed within the past three years.

PS-3 Design Requirements

A. The CONTRACTOR shall be responsible for designing the pre-engineered structure in conjunction with the metal building Manufacturer.

B. General Design Requirements:

1. CONTRACTOR and Manufacturer shall abide by all applicable local, state, or national building codes, laws, regulations, and safety standards.

2. The pre-engineered structure shall be designed in accordance with the latest intermodal design standards published by the COMPANY, Automatic Gate System (AGS) equipment provider requirements, and the project site, structural, and electrical plans. Any conflicts between these documents shall be brought to the COMPANY's attention for further clarification.

3. The design submitted by the CONTRACTOR shall include structural framing, exterior sheeting, roof design, roof drain system, joints, door/openings, anchor bolts, and conduit layout.

4. The pre-engineered structure shall meet all design load requirements stipulated by both local building codes and the project plans. In cases of conflict, the most restrictive load requirements prevail. Design loads shall be combined to produce maximum stresses within the structure.

5. Design and execution of the pre-engineered structure must comply with section MF – Metal Fabrication and other sections of these specifications.

6. At minimum, the CONTRACTOR shall consider the following loads in designing the pre-engineered structure:

a. Building Dead Load

b. Roof Live Load applied on the horizontal projection of the roof in accordance with Federal, State, and local building codes and MBMA practices.

c. Wind Loads applied as pressure and suction.

d. Roof Snow Load applied on the horizontal projection of the roof.

e. Ground Snow Load.

f. Design shall also consider local snowdrift conditions.

7. CONTRACTOR is responsible for obtaining any permits applicable to the pre-engineered structure and foundation.

8. The pre-engineered structure shall be design to minimum deflection requirements stipulated by the applicable local building code.

9. The proposed roof shall be designed with gutters and downspouts to direct runoff into ditches, catch basins, or other drainage structures noted in the project plans.

10. The design shall accommodate any conduit, lighting, or other electrical equipment noted in the project electrical plans.

C. Specific Design Requirements:

1. Camera Portal Structures:

a. The COMPANY shall provide foundation designs and geotechnical data for each proposed camera portal.

b. The CONTRACTOR shall coordinate work with the COMPANY's project ENGINEER to coordinate any foundation design revisions needed to accommodate the camera portal structure.

2. Canopy Structures:

a. The CONTRACTOR shall provide foundation designs and calculations as part of the design submittal for all proposed canopy structures. Foundation designs and calculations shall be signed and sealed by a Structural ENGINEER licensed in the same State as the proposed structure.

b. The COMPANY shall provide geotechnical data for the proposed canopy structures.

c. Design foundations for applicable loads, combinations of loads, and building reactions in accordance with the applicable local building codes and soil conditions.

d. No work shall proceed on AGS gate pads or within the footprint of the proposed canopy structure until the proposed canopy design submittals have been approved by the COMPANY.

D. SUBMITTALS:

1. A Structural ENGINEER licensed in the same State as the proposed structure shall prepare and sign a written certification attesting that the pre-engineered structure meets the applicable codes and authorities of the jurisdictions applicable to the project site.

2. The CONTRACTOR shall provide the erection drawings, structural calculations, manufacturer's specifications and product data, color samples, and other documents relevant to the construction of the camera portal. Structural calculations and erection drawings must be signed and sealed by a Structural ENGINEER licensed in the same State as the proposed structure.

3. Prior to submission, the CONTRACTOR shall provide a copy of any permit documents or drawings to the COMPANY for approval.

4. All pre-engineered structure design submittals are subject to approval by the COMPANY prior to ordering materials.

5. The CONTRACTOR may not order materials or submit permit materials for the proposed structure without prior approval by the COMPANY.

PS-4 Material

A. General Requirements

1. Use all means necessary to protect materials from damage during transport, storage, erection, and construction.

2. In the event of damage to any materials used in the pre-engineered structure, the CONTRACTOR shall immediately make all repairs and replacements necessary at no cost to the COMPANY.

3. Store all materials on platforms or pallets above grade, and protect all materials from weather-related deterioration.

4. Store metal panels/sheets in a manner that will allow them to drain freely and prevent moisture between panels. Do not store metal panels/sheets in contact with other materials that may cause staining.

5. Provide a twenty-year warranty on wall and roof paint finishing, and a one-year standard warranty on all other materials.

6. All paint to be stored and applied per manufacturer's instructions. Paint colors to be selected by the COMPANY from the Manufacturer's standard colors.

7. Exterior panels shall have a finish side coated with a full coat of polyester paint baked on over an epoxy primer. Reverse side shall be protected by a white wash coat applied over an epoxy primer.

B. General Structural Components:

1. At minimum, ASTM A36 structural steel shall be used with minimum stress of 36,000 psi unless otherwise noted.

2. CONTRACTOR shall provide electrical access openings, cover plates, and conduit couplings on structural members as appropriate.

C. Canopy Structural Components:

1. Structural Columns:

a. Structural columns shall be sized to meet or exceed specific project design load requirements.

b. Structural steel tubing shall be used. At minimum, material shall be ASTM A500 Grade B with a minimum yield stress of 46,000 psi.

2. Wide flange structural beams shall be used.

3. Deck Panels:

a. Deck panels shall not be spliced, and shall be fastened to the wide flange beams with a pre-punched clip system that requires no "thru the panel" fasteners.

b. Deck panels shall be 24-guage x 12" wide x 1-3/4" steel panels. Use ASTM A446 with a minimum yield stress of 50,000 psi having a G90 galvanized surface meeting ASTM A525.

4. Laminated Fascia Panels:

a. 24-gauge sheet steel shall be used.

b. G90 hot dipped galvanized, tension leveled, and extra smooth on exterior face of panel.

c. Fascia shall be factory preassembled and self-flashing.

d. No exposed fasteners on bottom or exterior face.

e. Panel core material shall consist of 2"-thick virgin expanded polystyrene in 1.5 PCF density.

f. All fasteners shall be galvanized steel.

D. Roof Drainage System:

1. Provide for roof drainage that directs runoff into downspouts located on exterior support columns or the exterior wall of the structure.

2. Unless shown on plans, no exposed gutters may be installed on canopy fascia. Gutters may be used on camera portal structures.

3. Downspouts shall be of one continuous length.

4. Downspouts shall be coated with a full coat of polyester paint baked on over an epoxy primer.

5. Roof drainage system shall include underground outlet pipes directing downspout flows to location specified on plans. Underground outlet pipe shall conform to NS Standard Specifications for Drainage.

6. Camera portal underground drains may tie into belly camera outlet pipe unless otherwise noted in the plans.

E. Belly Camera Drainage:

1. Work shall include class 52 DIP vertical drain pipe and grate for the belly camera recess area. Vertical drain work includes connection to outlet pipe shown in plans.

2. Drainage work shall conform to NS Standard Specifications for Drainage.

3. Vertical drain pipe is included in camera portal scope of work, and outlet pipe shall be paid as a separate bid item.

PS-5 Erection

A. General:

1. The CONTRACTOR is responsible for safely furnishing and installing the proposed camera portal structure.

2. The CONTRACTOR shall supply all materials in accordance with the approved design submittals.

3. The CONTRACTOR shall comply with all applicable local, state, and national rules and regulations concerning the installation of the proposed camera portal structure. Work shall be accomplished by a trained, competent erector having adequate experience in the erection of pre-engineered canopy systems.

4. Erect framing in accordance with MBMA Low-Rise Building Systems Manual, Common Industry Practices.

5. The CONTRACTOR shall handle all materials to avoid damage, including protecting factory finishes from abrasion. The CONTRACTOR shall replace any damaged materials.

6. The CONTRACTOR shall comply with all manufacturers' requirements. No structural members shall be altered or field cut without the approval of the manufacturer, the COMPANY, and the Professional ENGINEER who signed and sealed the design documents.

7. The CONTRACTOR shall furnish any temporary guys or bracing where needed. The CONTRACTOR is responsible for ensuring that the structure is adequately braced during construction. All temporary structural members shall be removed upon completion of the structure.

8. Do not cut or alter structural members without approval of the manufacturer.

B. Structural Components:

1. Erect true to line, level, and plumb. Brace and secure with temporary bracing in all directions as required.

2. Level base plates and secure to anchor bolts to level plane with full bearing to foundation supporting structures.

3. Place on supporting work, adjust and align in accurate locations and spacing before permanently bolting or welding in final location.

C. Wall and Roofing Systems:

1. Install in accordance with manufacturer's instructions.

2. Exercise care when cutting prefinished material to ensure cuttings do not remain on finished surface.

3. Fasten cladding system to structural supports – aligned, leveled, and plumb.

4. Install roof panels in such a manner to permit drainage to eaves of building or gutters. Install wall panels with vertical edges plumb.

5. Arrange and nest sidelap joints away from prevailing winds where possible.

6. Maintain application true to grid lines and avoid panel creep.

7. Protect factory finishes from mechanical, chemical, or other damage.

8. Apply all exterior panels for neat and watertight enclosure.

9. Remove all shavings from roof and walls as erection is completed.

10. Align bottoms of panels to provide proper coverage and fasten with in accordance with manufacturer's instructions.

11. Install all accessories or other items in accordance with manufacturer's instructions.

D. Camera Bridge:

1. The COMPANY's AGS technology provider shall supply a camera bridge for each camera portal structure being installed.

2. The CONTRACTOR shall erect the camera bridge in accordance with the AGS technology provider's instructions.

PS-6 Measurement and Payment

A. Measurement and payment for the proposed pre-engineered structure shall be paid per each structure installed, unless otherwise specified on the project bid sheet. This unit includes furnishing and installing the pre-engineered structure, foundation, lighting, electrical work, roof drain system, and other incidentals necessary to complete the work as specified and to provide a fully-operating structure.

END OF SECTION

Section SC – Structural Concrete

SC-1 Description

The Work shall consist of furnishing and placing structural concrete, unreinforced or reinforced, as shown on the plans. Concrete for concrete collars for culvert extensions is specified in Section DR - Drainage of this Specification. Concrete for slabs and concrete pavement is specified in Section CP - Concrete Pavement of this Specification.

SC-2 General Conditions

A. The CONTRACTOR shall furnish and deliver to the jobsite the required materials specified on the plans or in these Specifications. CONTRACTOR shall unload and stockpile materials in an orderly manner at locations designated by the ENGINEER.

B. Materials shall be protected from damage due to weather. No deteriorated or damaged material shall be used.

C. CONTRACTOR shall submit shop drawings for steel reinforcements, construction joint layout, and mix design for approval by the ENGINEER before work begins.

SC-3 Material

A. Cement shall conform to the following:

1. Standard Concrete - Cement shall be Portland cement, Type I, IA, II or IIA, conforming to the requirements of ASTM C 150.

2. High-Early Strength - Cement shall be Portland cement, Type III or IIIA, conforming to the requirements of ASTM C 150.

3. The type of cement shall be as shown on the plans.

B. Air-entraining admixture shall be of the neutralized vinsol resin type and conform to the requirements of ASTM C 260. The percentage of air-entrainment shall be as shown on the plans or as specified by the ENGINEER.

C. Admixtures, except air-entraining agents, used to alter the normal properties of concrete shall be used only upon the approval of the ENGINEER and conform to the requirements of ASTM C 494. Chemical admixtures for flowing concrete shall conform to the requirements of ASTM C 1017.

D. Coarse and fine aggregate shall conform to the requirements of AASHTO M 80 and AASHTO M 6, respectively, and meet the following requirements:

1. Aggregate containing particles including opaline, reactive with alkalis, shall not be used unless used with low alkali (less than 0.6 percent) cement.

2. Gradation shall be as shown in subsection SC-5 Composition of Mixes.

3. Aggregate shall meet the following impurities limits:

Description:	Maximum Percent by Weight	
	Fine	Coarse
Clay lumps	1.0%	0.25%
Coal and lignite	1.0%	0.25%
Alkali	Trace	Trace
Material finer than a No. 200 sieve	4.0%	0.5%*
Other deleterious substances (such as shale, mica, coated grains, soft and flaky particles)	3.0%	-
Soft fragments	-	2.0%
Other deleterious substances (such as friable, thin, elongated, or laminated pieces)	-	1.0%

** When the material finer than the No. 200 sieve consists essentially of crusher dust, the maximum amount permitted shall be 1.5 percent.*

E. Water shall meet the following requirements:

1. Water shall be reasonably clear and free from oil, salt, sugar, acid, alkali, organic and other injurious substances.

2. Water shall be tested in accordance with and meet the requirements of AASHTO T 26 unless known to be of potable quality.

3. Water shall not contain impurities in excess of the following limits:

   a. Acidity or alkalinity (as $CaCO_3$): 0.05%

   b. Total organic solids: 0.05%

   c. Total inorganic solids: 0.05%

4. Where the source of water is relatively shallow, the intake shall be so enclosed to exclude silt, mud, grass, or other foreign materials.

5. Non-potable water may be used if mortar cubes made with the water in question have 7 and 28 day strengths equal to at least 90% of similar specimens made with the sand cement and potable water. Testing shall be done in accordance with AASHTO T 71.

F. Reinforcing bars shall meet the following requirements:

1. Bars shall be intermediate grade, new deformed billet steel, conforming to the requirements of ASTM A 615, Grade 40 or 60.

2. Size, grade, shape and length shall be as shown on the plans.

3. Bars shall be free from dirt, paint, oil, grease, thick rust and other foreign substances.

4. Reinforcing bars shall be accurately cold bent to the shapes and dimensions specified. The minimum bend diameter shall be as shown in the table below, except that for sizes No. 3 to No. 11, inclusive, Grade 40 bars, the minimum diameter shall be 5 bar diameters.

   a. Bar sizes No. 3 through No. 8: 6 bar diameters minimum (Grade 60)

   b. Bar sizes No. 9 through No. 11: 8 bar diameters minimum

   c. Bar sizes No. 14 and No. 18: 10 bar diameters minimum

5. Bars shall be bent in the plane for which they were designed. Maximum allowable deviation for No. 7 bars and under shall be 1/2 inch out of plane and for No. 8 bars and over 1 inch out of plane.

6. Reinforcement supports shall be all plastic or all stainless steel.

G. Tie wires used for tying reinforcing bars shall be a minimum diameter of No. 16 gauge, black, soft iron wire.

H. Dowels shall be made from new, deformed billet steel conforming to the requirements of ASTM A 615, Grade 60.

I. Anchor bolts shall be of the type and of the diameter as shown on the plans.

J. Epoxy bonding compound shall conform to the requirements of ASTM C 881, Type II, Grade 1 or 2, and shall be subject to the approval of the ENGINEER.

K. Water stop shall be polyvinyl chloride (PVC) made from virgin raw materials and shall conform to the requirements of the U.S. Army Corps of Engineers Specification CRD C 572.

L. Grout for anchor bolt and dowel placement shall be non-shrink, non-metallic and conform to the requirements of ASTM C 1107 and CRD C 632, Grade B. The minimum compressive strength after 28 days shall be 5,000 psi.

M. Non-epoxy bonding compound shall conform to ASTM C 1059 Type II. Compound shall be only used when joining new to existing concrete where bonding compound cannot be placed immediately prior to pouring new concrete.

N. Preformed expansion joint filler shall conform to the requirements of ASTM D 1751.

O. Curing coverings shall meet the following requirements:

1. Coverings may consist of hay, straw, burlap, liquid membrane-forming compounds, white polyethylene sheeting, or waterproof paper.

2. Hay or straw must be free of objects such as sticks, stones, or ingredients that might damage or discolor the concrete surface.

3. Burlap shall conform to the requirements of AASHTO M 182, Class 3 or 4.

4. Liquid membrane-forming compounds shall conform to the requirements of AASHTO M 148, Type 2 (white pigmented). Type 1 (clear or translucent) may be used when shown on the plans or as directed by the ENGINEER.

5. Polyethylene sheeting shall be white opaque and conform to the requirements of AASHTO M 171.

6. Waterproof paper shall be white and conform to the requirements of AASHTO M 171.

SC-4 Equipment

A. Equipment and tools necessary for handling materials and performing all parts of the Work shall be approved by the ENGINEER as to design, capacity and mechanical condition. The equipment shall be at the jobsite sufficiently ahead of the start of construction operations to be examined. Any equipment not maintained in satisfactory working order, or which is proved inadequate, shall be improved or new equipment substituted, as directed by the ENGINEER.

B. Batching plant equipment shall meet the following requirements:

1. The batching plant shall include bins, weighing hopper and scales for fine aggregate and for each size of coarse aggregate.

2. If cement is used in bulk, a separate bin, hopper and scale for cement shall be included. The weighing hopper shall be properly sealed and vented to preclude dusting during operation.

3. Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

4. Scales for weighing aggregates and cement shall meet the following requirements:

   a. The scales for weighing aggregates and cement shall be inspected, approved and sealed in accordance with the requirements of the appropriate state or local regulating agency.

   b. Scales shall be inspected and sealed as often as the ENGINEER may deem necessary to assure their continued accuracy. The CONTRACTOR shall have on hand not less than 50 pound weights for frequent testing of all scales.

   c. Batching plants equipped to proportion aggregates and bulk cement by means of automatic weighing devices may be used.

5. Water measuring equipment shall meet the following requirements:

    a. Unless the water is weighed, the water measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled.

    b. The measuring tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tank.

    c. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

6. A positive, automatic mechanical method shall be used for adding admixtures in solution.

7. Mixers at the jobsite or at a central location shall meet the requirements of subsection SC-7 Mixing and Delivery.

C. Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central mixed concrete shall conform to the requirements of AASHTO M 157.

D. Non-agitator trucks shall meet the following requirements:

1. Bodies of non-agitating trucks hauling concrete shall be smooth, mortar tight, metal (non-aluminum) containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation.

2. The concrete shall be discharged from the bottom of the container. If discharge is accomplished by tilting the body, the surface of the load shall be retarded by a suitable baffle.

3. Covers shall be provided when needed for protection.

E. Internal mechanical vibrators shall be of sturdy construction, adequately powered, capable of transmitting vibration to the concrete in frequencies of not less than 3,500 impulses per minute and shall produce a vibration of sufficient intensity to consolidate the concrete into place without separation of the ingredients.

F. Forms shall meet the requirements of subsection SC-10 Forms.

SC-5 Composition of Mixes

A. The following concrete mix table shall be used as a guide with exact quantities to be determined by the CONTRACTOR to take into account local variation in materials. In addition, established state highway department mixes meeting the recommended criteria may be substituted subject to the approval of the ENGINEER.

Structural Concrete Mix Table						
Class of Concrete	Min. 28-Day Compressive Strength (PSI)	Coarse Aggregate Size No.*	Cement (Sacks/C.Y. of Concrete)	Max. Water-Cement Ratio (Gals./Sack)	Maximum Slump (in.)	Maximum Air Content (% Volume)
A50-A	5,000	57, 67, 68	7.18	4.97	4	2.5 - 6.0
A45-A	4,500	56, 57, 67	7.18	5.19	4	2.5 - 6.0
A40-A	4,000	56, 57, 67	6.76	5.30	4	4.0 - 8.0
B35-A	3,500	56, 57, 67	6.76	5.19	4	3.5 - 7.0
B30-A	3,000	57	6.60	5.50	4	3.0 -5.0
B30	3,000	57	6.60	6.00	4	0
C	2,000	57	5.40	6.75	4	0

** Size No. per AASHTO M 43*

B. As an alternate to the Concrete Mix Table, the CONTRACTOR may supply a concrete mix which meets the specified concrete strength. An alternate mix design shall be approved by the ENGINEER before use. Alternate mix designs shall be determined as follows:

1. Method 1 - Without preliminary strength test.

   a. If suitable data from trial batches or field experience is not available, permission may be granted to base concrete proportions on the water-cement ratios shown in the following table.

Minimum 28-Day Compressive Strength (PSI)*	Maximum Permissible Water-Cement Ratio (Gals./Sack)	
	Non-Air-Entrained Concrete:	Air-Entrained Concrete:
5,000	3.50	**
4,500	4.29	3.39
4,000	4.97	3.95
3,500	5.76	4.51
3,000	6.55	5.19
2,500	7.33	6.09
2,000	8.12	7.00

** 7 day strengths for Type III and IIIA concrete.*

*** For compressive strengths above 4,500 psi for air-entrained concrete, proportions shall be selected by Method 2.*

2. Method 2 - With preliminary strength tests.

   a. Water-cement ratios, other than those shown in the table above, may be used when preliminary test results or field data is available.

   b. Proportions shall be selected to produce a required compressive strength exceeding the specified compressive strength as outlined in the current editions of "ACI 318" and "ACI 214" or as follows:

i. A curve shall be established showing the relationship between the water-cement ratio and compressive strength. The curve shall be established by plotting at least three points representing batches which produce strengths above and below that required with each point representing the average of at least three test specimens tested at 28 days or the earlier age designated.

ii. The maximum water-cement ratio for the required compressive strength shall be that shown by the curve to produce strength 15 percent greater than the specified strength.

3. For alternate mix designs, the following air contents, when air-entrained concrete is required, shall be adhered to:

Maximum Size Coarse Aggregate (Inches)	Air Content (% by Volume)
1-1/2, 2 or 2-1/2	5 ± 1
3/4 or 1	6 ± 1
3/8 or 1/2	7 ± 1

4. An alternate mix design may be approved by the ENGINEER without preliminary testing if such mix is in close conformity to approved mixes.

C. Concrete that is subject to freezing temperatures while wet shall have a maximum water-cement ratio of 5.98 by volume and shall be air-entrained.

SC-6 Measurement of Materials

A. Bulk cement is required for all uses unless the ENGINEER permits the use of bag cement. Cement shall be measured by weight to an accuracy of plus or minus 1 percent.

B. Aggregates shall be measured by weight to an accuracy of plus or minus 2 percent. CONTRACTOR shall be responsible for insuring that adjustments are made in the mix due to surface moisture on the aggregate. Weight shall be based on a saturated, surface dry condition.

C. Water shall be measured by weight or volume to an accuracy of plus or minus 1 percent.

D. Admixtures shall be measured by weight or volume with an accuracy of plus or minus 3 percent.

SC-7 Mixing and Delivery

A. Concrete may be mixed at the job site, at a central point, or wholly or in part in truck mixers.

B. The following requirements shall apply to all mixers and the mixing process unless otherwise specified:

1. Mixer shall not be operated in excess of its nominal capacity as shown on the manufacturer's rating plate.

2. Mixer shall be operated at the drum speed recommended by the manufacturer.

3. When discharged, their contents shall be removed before materials are placed in for the next batch.

4. Mixers shall ensure a uniform distribution of ingredients throughout the mass.

5. Upon cessation of mixing for more than 30 minutes, the drum shall be thoroughly cleaned.

C. Mixing at the jobsite shall be in accordance with the following:

1. The mixing time shall not be less than one minute for mixers having a capacity of one cubic yard or less with an increase of 15 seconds for each cubic yard, or portion thereof, of additional mixing capacity.

2. For mixers with a capacity in excess of 3 cubic yards, the minimum mixing time may be reduced to 1-1/2 minutes provided that the mixture is a homogeneous, uniform mass.

3. Other mixing times shall be subject to the approval of the ENGINEER.

4. Mixing time shall be measured from the moment all solid materials are placed in the mixer drum, provided that all water is added before one-fourth of the mixing time has elapsed. About 10 percent of the mixing water shall be added to the drum before the solid materials.

D. Ready-mixed concrete may consist of central-mixed, shrink-mixed, or truck-mixed concrete.

E. Central-mixed concrete may be delivered in a truck agitator, a truck mixer operating at agitating speed, or a special non-agitating truck.

F. Shrink-mixed concrete shall be initially mixed in a stationary mixer a minimum of 30 seconds. Final mixing shall be done in truck mixers with concrete to be discharged before the drum or blades have exceeded 300 revolutions. In addition, truck mixing at mixing speed shall not exceed 100 drum or blade revolutions.

G. Truck mixed concrete shall meet the following requirements:

1. Truck-mixed concrete shall be completely mixed in the truck with the mixing beginning within 30 minutes after loading.

2. Concrete shall be mixed for not less than 70 nor more than 150 revolutions at mixing speed. A maximum of 300 revolutions shall be allowed with revolutions in excess of 150 at agitating speed.

H. Special non-agitating trucks shall be subject to the approval of the ENGINEER. Use of this equipment shall require that discharge shall be completed within 30 minutes after introduction of the mixing water to the cement and aggregates.

I. In addition to the above requirements, the following requirements shall apply:

1. All concrete must be discharged from the mixer within 1-1/2 hours after the introduction of all water provided the air or concrete temperature does not exceed 70°F. When the temperature exceeds 70°F a time limit of 1 hour will be required.

2. Time limits for discharging shall be shortened by 15 minutes when Type IIIA cement is used.

3. The time limit for delivery by any method may be extended by a specified amount with the use of approved admixtures.

4. The ENGINEER may permit mixing and the adding of the cement and additives at the jobsite in truck mixers in order to meet the time limits.

SC-8 Cold Weather Concreting

A. The CONTRACTOR shall adhere to cold weather concreting practices in accordance with ACI 306R and the measures indicated in this section..

B. Cold weather concreting shall require that all snow, ice and other frozen material be removed from the site.

C. Concrete shall not be placed when the ambient air temperature is below 40°F unless authorized by the ENGINEER.

D. The CONTRACTOR shall place and maintain concrete at the following temperatures for a given section thickness:

1. <12 inches: 55°F

2. 12-36 inches: 50°F

3. 36-72 inches: 45°F

4. >72 inches: 40°F

E. Concrete shall be maintained at the appropriate temperature for least 72 hours after placement to allow for initial curing. Maintain concrete at at least 32°F for the remainder of the specified curing period.

A. The CONTRACTOR shall have adequate equipment and means available to heat concrete materials. The equipment used shall heat the mass uniformly to avoid hot spots.

B. When concreting is authorized at temperatures less than 40°F, the aggregates and water shall be heated to not less than 70°F and not more than 150°F.

C. Any variance to the limiting construction temperatures shall be subject to the ENGINEER's approval but shall not relieve the CONTRACTOR's responsibility for satisfactory results.

D. Reinforcement bars, forms, fillers, and other materials in contact with concrete shall not be less than 35°F at time of pouring. Preheat if temperature falls below 35°F.

SC-9 Hot Weather Concreting

A. The temperature at the time of placement during hot weather shall not exceed 90°F. Any variance to this temperature limit shall be subject to the ENGINEER's approval but shall not relieve the CONTRACTOR's responsibility for satisfactory results.

B. The CONTRACTOR may cool the aggregates by fogging, sprinkling, or other suitable means so long as there is no variation in the moisture content.

C. Crushed or flaked ice may be used as a portion of the mixing water on a pound for pound basis so long as all ice is melted before placement of concrete.

D. Water may be cooled by refrigeration.

E. Cooling of the forms and reinforcing steel shall be acceptable except that pools of water within the forms shall not be allowed.

F. Rate of evaporation from concrete shall not exceed 0.2 $lb/in^2/hr$ based on ACI 305R Table 2.1.5. CONTRACTOR shall apply fog spray, evaporation retardants, or other measures to stay below this rate.

SC-10 Forms

A. Forms shall meet the following requirements:

1. Forms shall be constructed of wood, steel or other suitable material, and of type, size, shape, quality and strength which shall produce true, smooth lines and surface conforming to the lines and dimensions of the concrete structure as shown on the plans.

2. Form lumber for all exposed surfaces shall be dressed at least on one side and 2 edges.

3. All forms shall be clean and free of chips, sawdust, ice, dirt or other foreign material.

4. Unless directed otherwise, forms shall be chamfered 3/4 inch at exposed edges.

5. Reuse of forms shall be allowed only if they are cleaned and oiled prior to reuse. Forms that are split, warped, or cracked shall not be allowed.

B. Construction of forms shall conform to the following:

1. Forms shall be constructed mortar-tight, and shall be made sufficiently rigid by the use of ties and bracing to prevent displacement or sagging and to withstand the pressure and vibration without deflection and/or objectionable distortion from the prescribed lines during and after placement of the concrete.

2. Joints shall be horizontal or vertical and suitable devices shall be used to hold adjacent edges together in accurate alignment.

3. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage of lumber.

4. Forms shall be constructed so that they can be readily removed without damaging concrete.

5. Bolts and rods shall be used for internal ties. They shall be so arranged that, when the forms are removed, no metal shall be within 1 inch of any surface.

6. All fittings for metal ties shall be of such design that upon their removal the cavities which are left will be the smallest practicable size. The cavities shall be filled with cement mortar and the surface left sound, even and uniform in color with respect to the original surface.

7. The inside surface of forms shall be coated with a ready-to-use, nonstaining form release agent such as clear oil or lacquer. A thin film shall be applied to all surfaces that shall be in contact with the fresh concrete.

8. In metal form construction all fasteners in contact with concrete shall be countersunk.

C. The removal of forms shall meet the following requirements:

1. Forms shall not be removed until the concrete has adequately hardened and has acquired sufficient strength to support its weight and any construction load that may be placed on it.

2. Forms shall be removed in such a manner as to insure the complete safety of the structure. Care shall be taken to preserve form sections and not damage the corners or surfaces of the concrete. Hammering or prying between forms and concrete shall not be permitted. If it is necessary to use wedges to loosen forms, only wood wedges shall be used.

3. Removal of forms shall depend on the type of concrete, the location of the form, and the temperature and moisture conditions which affect the strength of the concrete. Forms may only be removed as directed by the project Plans and approved by the ENGINEER. If not otherwise specified on the plans or by the ENGINEER, the following may be used as a guideline:

    a. For concrete not subject to direct stress and not reliant on forms for vertical support, forms may be removed after the concrete has achieved a required minimum strength of 500 psi.

    b. For concrete subject to appreciable direct stress, partially reliant on forms for vertical support, and subject to dead loads only, forms may be removed after the concrete has achieved a required minimum strength of 750 psi.

    c. For concrete subject to appreciable direct stress, partially reliant on forms for vertical support, and subject to dead and live loads, forms may be removed after the concrete has achieved a required minimum strength of 1,000 psi.

    d. For concrete subject to high stress and wholly reliant on forms for vertical support, forms may be removed after the concrete has achieved a required minimum strength of 2,000 psi.

SC-11 Placing Reinforcement

A. Reinforcement shall be inspected and approved by the ENGINEER before placement of the concrete.

B. Reinforcement shall be placed, as specified in this section and as shown on the plans, and adequately supported before concrete is placed and shall be secured against displacement.

C. Reinforcement supported from the ground shall rest on precast concrete blocks not less than 4 inches square and having a compressive strength equal to or greater than the specified compressive strength of the concrete being placed.

D. Reinforcement supported from formwork shall rest on bar supports and spacers made of concrete, metal, plastic, or other materials approved by the ENGINEER.

E. Where noted on the plans and at all formed surfaces that shall be exposed to the weather in the finished structure, bar supports and side form spacers spaced no more than 4 feet on centers shall be provided. Bar supports and spacers and all other accessories within 1/2 inch of the concrete surface shall be non-corrosive or protected against corrosion.

F. Unless otherwise shown on the plans, the minimum clear distance from the face of concrete to any reinforcement shall be as follows:

    1. Where concrete is deposited directly against the ground, 3 inches of cover shall be maintained.

2. At other surfaces, minimum cover shall be 2 inches for No. 6 through No. 18 bars and 1-1/2 inches for No. 5 and smaller bars.

G. No bending of partially embedded bars shall be allowed.

H. Do not place bars having kinks or bends other than those included on the project Plans or shop drawings approved by the ENGINEER.

I. Splicing of reinforcing bars shall be as shown on the plans and shall conform to the requirements of the AWS D1.4. Butt welding shall not be allowed. Splices must be located such that the entire lap is placed within one concrete pour.

J. Exposed reinforcing bars intended for bonding with future extensions shall be protected from rust and corrosion by use of adequate covering.

K. Tack welding of reinforcing bars is prohibited.

L. Reinforcement shall be continuous through construction joints.

M. Reinforcement shall be clean and free from loose scale, dirt, grease, oil, form release agent, dried concrete, thick rust, or other materials that reduce concrete bonding.

SC-12 Placing of Concrete

A. Before placement of the concrete, all debris, ice, snow, or other harmful substances shall be removed from the space to be occupied by the concrete.

B. Where concrete is to be placed on a rock foundation, all loose rock, clay, mud, etc., shall be removed from the surface of the rock. Any unusual conditions or excess fissures shall be treated as directed by the ENGINEER.

C. Water shall be removed from the space to be occupied by the concrete before concrete is deposited, unless otherwise directed by the ENGINEER. Any flow of water into an excavation shall be directed through proper side drains to a sump, or be removed by other approved methods which will avoid washing the freshly deposited concrete.

D. Concrete shall be handled in such a manner as to place the material as rapidly as practical by methods which will prevent the separation or loss of ingredients. When placing is started, it shall be a continuous operation until the panel or section is completed.

E. Special care shall be taken to fill each part of the forms by depositing concrete near final position as possible, to work the coarse aggregate back from the face and to force the concrete under and around the reinforcement without displacing it. Depositing a large quantity at any point and working it to final position shall not be allowed.

F. Concrete that is partially set shall not be used.

G. Concrete shall not have a free fall of more than 5 feet unless through an approved metal chute or tube. The minimum diameter of the downspout shall be 4 inches.

H. Concrete shall be placed in uniform layers of between 6 to 12 inches deep and each layer shall be placed and consolidated before the next layer is placed.

I. No construction joints shall be allowed unless shown on the plans or directed by the ENGINEER. All pours shall be monolithic where possible. Retempering (remixing) of concrete shall not be allowed.

J. Concrete shall be thoroughly worked during the placing by means of approved tools. The working shall be such as to force the coarse aggregate from the surface and to bring the mortar in contact with the forms and reinforcement to produce a smooth finish free of voids or honeycomb.

K. Concrete shall be thoroughly compacted during and immediately after depositing by vibrating the concrete internally by means of mechanical vibrating equipment as follows:

   1. Vibrator shall be inserted into the concrete at the point of deposit and in the areas of freshly placed concrete.

   2. The time of vibration shall be of sufficient duration to accomplish thorough consolidation, complete embedment of the reinforcement, the production of smooth surfaces free from honeycomb and air bubbles, and to work concrete into all angles and corners of the forms. However, over-vibration shall be avoided, and vibration shall continue in one spot only until the concrete has become uniformly plastic and shall not continue to the extent that pools of grout are formed. The length of time of vibration shall be determined in the field.

   3. Vibrators shall be applied at overlapping points and shall not be used to move masses of concrete.

L. The use of surface vibrators to supplement internal vibration shall be permitted when satisfactory surfaces cannot be obtained by the internal vibrations alone and when the CONTRACTOR has obtained the approval of the ENGINEER of the equipment to be used. Surface vibrators shall be applied only long enough to embed the coarse aggregate and to bring enough mortar to the surface for satisfactory finishing.

M. Vibrators shall not be attached to nor allowed to contact forms or reinforcement or to penetrate beyond any layer of fresh concrete.

N. Hand methods of consolidation shall be allowed on small jobs provided that acceptable tools such as spades or puddling sticks are used.

SC-13 Testing

A. Slump tests shall be performed by the CONTRACTOR and shall meet the following requirements:

1. In general, the test shall be performed at the start of operations each day, whenever the appearance of the concrete indicates a change in mix, or as directed by the ENGINEER.

2. The tests shall be performed in accordance with the requirements of ASTM C 143.

3. The slump range shall be 2-4 inches.

B. The air content of air-entrained concrete shall be checked at least each time test cylinders are cast. Changes in the air content above or below the amount specified shall be corrected by adjustments in the mix design or quantities of air-entraining agent being used.

C. Concrete strength tests shall meet the following requirements:

1. During the pouring of the concrete, the CONTRACTOR shall collect and mold 4 concrete cylinders from each pour.

2. The CONTRACTOR shall be responsible for keeping a record of the test cylinder, batch number, pour location and date.

3. Specimens shall be made and stored in accordance with the requirements of ASTM C 31.

4. Specimens shall be tested in accordance with the requirements of ASTM C 39.

5. The strength level of the concrete shall be considered satisfactory if no individual strength test result falls below the specified strength by more than 500 psi and the average of any 3 consecutive tests is equal to or greater than the specified strength.

SC-14 Joints

A. When the structures or portions of the structures are designed to be monolithic, they shall be cast integrally, except as hereinafter modified.

B. When necessary to provide construction joints not indicated on the plans, such joints shall be located as directed by the ENGINEER.

C. Construction joints shall be formed as follows:

1. Before new concrete is placed against hardened concrete, the surface of the hardened concrete shall be cleaned and all laitance removed.

2. After the hardened surface is cleaned and immediately before the new concrete is placed, the existing surfaces shall be thoroughly wetted and all standing water removed.

3. A thin bonding layer of mortar, usually 1/8 inch to 1/2 inch in thickness, shall be spread on the moist concrete surface. Mortar shall be mixed as dry as practicable and shall consist of a ratio of fine aggregate to cement of 2:1. In lieu of mortar, a commercial bonding agent may be used, subject to the approval of the ENGINEER, when applied in accordance with the manufacturer's recommendations.

4. The reinforcement shall continue through the joint. There shall be no construction joint in the area of a reinforcement splice.

5. For unreinforced concrete, shearing strength shall be provide by means of keys or dowels as shown on the plans or as directed by the ENGINEER.

D. Watertight construction joints shall be not be used unless shown on the plans or as directed by the ENGINEER. Watertight construction joints shall be formed as follows:

1. Where a construction joint is required to resist water pressure, special care shall be taken in finishing the surface to which the succeeding concrete is to be bonded. The consistency of the concrete shall be carefully controlled and the surface shall be protected from loss of moisture.

2. A continuous key shall be constructed in the face of the first section of concrete placed with a water stop embedded in this first placement. One-half of the water stop is embedded in the first placement and the remaining material shall be embedded in the adjacent placement. The concrete shall be thoroughly vibrated to insure uniform contact over the entire surface of the water stop.

E. Expansion joints shall be provided for as shown on the plans or as directed by the ENGINEER and shall be formed as follows:

1. Expansion joints shall consist of a minimum 1/2 inch wide premolded joint filler or other suitable material.

2. No steel reinforcement shall be allowed to cross such joints.

3. Joints shall be sealed with a non-sag joint sealant.

4. If required, open joints shall be constructed by using removable inserts that will not chip or otherwise damage the concrete during removal.

SC-15 Finishing

A. Unless otherwise shown on the plans or directed by the ENGINEER, all formed surfaces shall be given a Class 1, Ordinary Surface Finish immediately after form removal.

B. Exposed formed surfaces shall also be given a Class 2, Rubbed Finish in addition to a Class 1 finish.

C. Class 1, ordinary Surface Finish shall consist of removing all fins, ridges, or irregular projections. Furthermore, all cavities, broken corners, honeycombed spots and other defects shall be cleaned, saturated with water and filled with mortar in 1/2 inch layers. Mortar shall be mixed as dry as practicable and shall consist of a ratio of fine aggregate to cement of 2:1.

D. Class 2, Rubbed Finish shall conform to the following:

1. Exposed concrete surfaces shall be wetted with water until saturated. Wetting shall not begin until any mortar applied under the Class 1 finish has set.

2. Surfaces shall be rubbed with a medium coarse carborundum stone, a wetted wooden block, or equal abrasive so that a paste will be brought to the surface. Rubbing shall continue until all marks, projections and irregularities have been corrected and all voids have been filled.

3. A final finish shall be obtained by using a fine carborundum stone and water. This shall continue until the entire surface is smooth and uniform in color.

4. After the surface has dried thoroughly, it shall be rubbed with dry burlap to remove all dried grout. Any section being cleaned shall be completed the same day so that no grout remains on the surface overnight.

5. As an alternate to a Class 2 finish, the CONTRACTOR may use form liners consisting of plastic coated plywood, plastic forms, or other acceptable materials that shall give a smooth and uniform surface.

SC-16 Curing

A. All concrete surfaces, except those surfaces protected by forms that remain in place 5 days or longer, shall be cured as stated hereinafter.

B. Curing shall begin as soon as the concrete has hardened sufficiently to withstand surface cleaning and immediately after forms have been removed from formed surfaces.

C. Surfaces requiring a Class 2 finish may have the covering temporarily removed for finishing, but the covering shall be restored as soon as possible.

D. Standard concrete shall be kept moist and at a temperature of between 50°F and 90°F for a period of 7 days after placement. High-early strength concrete shall be kept moist and in the temperature range for at least 3 days. Longer periods of curing may be required when temperatures are below 50°F.

E. Use of a fog or mist spray may be required during and after finishing until curing materials can be applied.

F. Failure to provide sufficient curing materials of whatever kind the CONTRACTOR may elect to use shall be cause for immediate suspension of concreting operations.

G. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

H. When concrete is being placed and the air temperature may be expected to drop below 35°F, a sufficient supply of straw, hay, or other suitable blanketing material shall be provided to protect the concrete. The CONTRACTOR shall be responsible for the quality and strength of the concrete placed during cold weather, and all concrete injured by frost action shall be removed and replaced at the CONTRACTOR's expense.

I. Curing materials shall conform to subsection SC-3 Materials.

J. Polyethylene coated burlap and white polyethylene sheeting shall be permitted as a curing application only on areas where intimate contact with the concrete surface can be obtained and maintained.

K. Burlap curing shall meet the following requirements:

1. The surface of the concrete shall be entirely covered with the mats.

2. Before placing, the mats shall be thoroughly saturated with water.

3. The mats shall be weighted down so as to remain in intimate contact with the surface covered and shall be maintained fully wetted.

L. Straw curing shall meet the following requirements:

1. When this type of curing is used, the concrete shall be cured initially with burlap mats, as specified above, until after final set of the concrete or, in any case, for 12 hours after placing the concrete.

2. As soon as the mats are removed, the surfaces to be cured shall be thoroughly wetted and covered with at least 8 inches of straw or hay, thickness to be measured after wetting.

3. The straw or hay shall be kept thoroughly saturated with water.

4. If the straw or hay becomes displaced during the curing period, it shall be replaced to the original depth and saturated.

5. Upon removal, the covering shall be properly disposed of. Removed straw or hay may be used for mulching in accordance with Section SM - Seeding and Mulching of these Specifications.

M. Curing by the use of a liquid membrane forming compound (white pigmented) shall meet the following requirements:

1. After the concrete has been finished, and immediately after the surface water has disappeared, the entire surface of the concrete shall be cured by mechanically applying thereon a uniform coating of the curing compound.

2. If conditions arise which prevent immediate application, the surface shall be kept wet until the application of the compound is started.

3. Joints shall be protected by an approved method so that the compound will not enter the joint.

4. The material shall be applied in 1 or 2 applications as directed by the manufacturer. When applied in 2 applications, the second shall follow the first within 30 minutes.

5. The compound shall be applied in a continuous uniform film by means of a power operated pressure spraying or distributing device at the rate specified by the manufacturer, but no less than one gallon per 150 square feet of surface.

6. The equipment for applying the compound shall provide for adequate agitation of the compound during application and shall be approved by the ENGINEER before work is started.

7. If the compound is too thick for satisfactory application during cold weather, the material may be warmed in a water bath at a temperature not over 100°F.

8. Thinning with solvents shall not be permitted.

9. Hand spraying of areas with irregular widths and shapes and surfaces exposed by the removal of forms shall be allowed.

10. Should the method of applying the compound produce a non-uniform film, its use shall be discontinued and the curing done by another method specified herein.

11. If rain should fall on the newly coated structure before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, a new coat of material shall be applied to the affected areas equal in curing rate to that specified for the original coat.

12. The treated surface shall be protected from injury until the expiration of the curing period

13. If there should be a breakdown of the spraying equipment, protection of the uncoated concrete shall be provided.

N. Curing using white polyethylene sheeting shall meet the following requirements:

1. The surfaces to be cured shall be entirely covered with polyethylene sheeting.

2. Sheets shall be overlapped a minimum of 18 inches.

3. The covering shall be weighed down so as to remain in intimate contact with the surface covered.

O. Curing using waterproof paper shall meet the following requirements:

1. The surfaces to be cured shall be entirely covered with waterproof paper..

2. Sheets shall be overlapped a minimum of 18 inches.

3. The covering shall be weighed down so as to remain in intimate contact with the surface covered.

4. Paper not manufactured in sizes providing the required width shall be securely sewed or cemented together, the joints being securely sealed in such a manner that they do not open up during curing.

5. The surface shall be thoroughly wetted before placing the paper.

SC-17 Waterproofing and Dampproofing

A. Waterproofing or dampproofing of concrete surfaces below the ground line shall be as shown on the plans.

B. Surfaces to be treated shall be clean and dry.

C. Concrete surfaces shall have been cured a minimum of 7 days for standard concrete and 3 days for high-early strength concrete, respectively, before being waterproofed or dampproofed.

D. Dampproofing shall conform to the following.

1. Surfaces to be dampproofed shall be covered with a uniform coat of hot primer at a rate of 1 gallon per 100 square feet.

2. After the primer has been allowed to cure, two successive uniform mop coats of hot asphalt or tar shall be applied at a rate of 4-1/2 gallons per 100 square feet per each coat. The first coat shall be allowed to cure before the second coat is applied

E. Waterproofing shall conform to the following:

1. Waterproofing shall begin at the low point of the surface to be waterproofed so that the water will run over and not against or along the laps. The first strip of fabric shall be half the width, the second shall be of full width, lapped the full width of the first

sheet, and the third and each succeeding strip shall be the full width and lapped so that there will be two layers of fabric at all points with three-layer lap for a distance of not less than 2 inches.

2. The procedure for applying primer and waterproofing with membrane fabric shall be as follows:

    a. Beginning at the low point of the surface to be waterproofed, the entire surface shall be mopped with a primer and allowed to cure.

    b. A section slightly more than half the width of the membrane fabric and for the full length of the surface shall be mopped with asphalt or tar and a half width of the fabric pressed into place.

    c. The half width of fabric and an adjacent section of the surface equal to slightly more than half the width of the fabric shall be mopped with asphalt or tar and a full width of fabric pressed into place, completely covering the first strip.

    d. Slightly more than half the second strip and an adjacent section of the concrete surface equal to slightly more than half the width of the fabric shall be mopped with asphalt or tar and the third strip of fabric shingled on so as to lap the first strip more than 2 inches. This process shall continue until the entire surface is covered with 2 layers of fabric.

    e. The entire surface shall be given a final mopping of asphalt or tar.

3. The completed waterproofing shall be firmly bonded membrane composed of 2 layers of fabric and 3 moppings of asphalt or tar, together with a coating of primer. Under no circumstances shall one layer of fabric touch another layer at any point, or touch the surface of the structure, unless separated from that layer by one coat of asphalt or tar.

4. On horizontal surfaces, not less than 12 gallons of asphalt or tar shall have been used for each 100 square feet of finished work; and on vertical surfaces, not less than 15 gallons shall have been used. Primer shall be applied at a rate of 1 gallon per 100 square feet.

5. The work shall be so regulated that at the close of a day's work all fabric that is laid shall have received the final mopping of asphalt or tar.

6. Special care shall be taken at all laps to see that they are thoroughly sealed.

F. No dampproofing or waterproofing shall be allowed when the temperature is below 35°F.

G. Asphalt shall be applied at a temperature between 300°F and 350°F.

H. Tar shall be applied at a temperature between 200°F and 250°F.

I. All bitumen shall be mopped or brushed on the surface except that spraying shall be permitted for prime coats.

J. The final coat shall be allowed to dry at least 2 days before any earth is allowed to contact the surface.

SC-18 Interfacing with Existing Concrete or Rock

A. Dowels shall be installed into the existing concrete or rock as follows:

1. Dowels shall be spaced as shown on the plans.

2. Horizontal dowel holes shall be drilled downward on a slope of approximately 1 inch per foot or as otherwise shown on the plans.

3. Dowels shall be grouted in place with an epoxy grout. Grout shall be applied in accordance with the manufacturer's recommendations.

B. The surface of the existing material to which the new concrete shall be bonded shall be prepared as follows:

1. The surface shall be cleaned by sandblasting, waterblasting, hammers or wire brushes, so that all foreign material and loose or unsound concrete is removed and that a clean sound surface remains.

2. The surface shall be washed with clean water or air cleaned with an oil free air to remove all dust.

3. Grease and oil shall be scrubbed and removed with a detergent and the surface washed with clean potable water.

C. The new concrete shall be bonded to clean sound material with an epoxy bonding compound. The bonding system shall be applied in accordance the manufacturer's recommendations. It is recommended that bonding compound be applied as a spray application by use of a bottom discharge pressure vessel operating at approximately 100 psi. Bonding compound shall not be applied to surfaces with visible or standing water.

SC-19 Faulty Concrete

A. If early tests of concrete indicate that the required 28 day strength may not be reached, the CONTRACTOR shall provide additional curing as directed by the ENGINEER.

B. If the concrete is faulty on account of low strength as indicated by test or faulty in other respects, the CONTRACTOR shall provide cores from the poured concrete if requested or shall remove and replace the faulty concrete, if so directed by the ENGINEER.

C. All costs incidental to faulty concrete, including any additional curing required, shall be borne by the CONTRACTOR.

SC-20 Measurement and Payment

A. Measurement

1. The quantity of reinforced or unreinforced structural concrete to be paid for will be the number of cubic yards of the appropriate type of concrete incorporated into the completed and accepted work. The number of cubic yards will be computed from dimensions shown on the plans or from revised dimensions authorized by the ENGINEER. No deduction will be made for the volume of encased reinforcement.

B. Payment

1. Payment for unreinforced structural concrete will be made at the Contract unit bid price per cubic yard in place for unreinforced structural concrete, which price shall constitute full compensation for furnishing all materials, equipment and labor necessary for placing the concrete and shall include dewatering, dampproofing and/or waterproofing, curing, excavation and backfill, finishing and testing, which shall include slump testing, air content testing, and the casting, curing, handling, shipping and testing of compression test cylinders.

2. Payment for reinforced structural concrete will be made at the Contract unit bid price per cubic yard in place for reinforced structural concrete, which price shall constitute full compensation for furnishing all materials, equipment and labor necessary for placing the concrete and shall include dewatering, reinforcing steel, dampproofing and/or waterproofing, curing, excavation and backfill, finishing and testing, which shall include slump testing, air content testing, and the casting, curing, handling, shipping and testing of compression test cylinders.

3. No separate payment will be made for hot or cold weather concreting precautions.

4. No separate payment will be made for the replacement of faulty concrete caused by weather conditions, deficiencies in structural strength, and/or CONTRACTOR's negligence.

5. No additional compensation will be allowed for the use of a higher strength concrete substituted by the CONTRACTOR for other classes of concrete. No allowance will be made for the use of additional cement or additives required for air-entraining concrete or other concrete additives.

6. Costs of preliminary strength testing for an alternate mix design will be borne by the CONTRACTOR. Costs for final strength testing will be included in the Contact unit bid price for concrete pavement. Any other strength testing performed for the benefit of the CONTRACTOR (such as determining an earlier time for form removal) will be paid for by the CONTRACTOR.

END OF SECTION

Division VII: Utilities

Section CA – Casing Pipe

Section CO – Electrical & Communications Conduit

Section SS – Sanitary Sewer

Section WL – Water Line

Section CA – Casing Pipe

CA-1 Description

The Work shall consist of the furnishing and installation of casing pipe for underground conduit, water lines and/or sanitary sewer.

The CONTRACTOR shall be responsible for locating the exact location of any existing sewer lines, water lines and/or any other utilities that may conflict with the installation. The CONTRACTOR shall endeavor to install the pipe casing without interrupting service and/or damaging other utilities. However, should service be interrupted and/or damage occur during the installation, the CONTRACTOR shall be responsible for quickly restoring service and/or repairing damage at no cost to the COMPANY.

CA-2 Use of Casing Pipe

A. Casing pipes shall be used for all utility crossings under tracks, including utilities owned by the COMPANY. Utility crossings include gas, fuel, pressurized liquids, steam, water lines, sanitary sewers, underground conduit, and other features as shown on the Plans.

B. Casing pipes for flammable and nonflammable gas pipelines may be omitted only as shown on the Plans provided that the carrier pipe meets the requirements provided in the AREMA Manual Chapter 1 Section 5.2.

C. Casing pipes are not required for drainage crossings unless shown on Plans.

D. Utility lines running parallel to tracks may be encased if shown on Plans.

CA-3 General Requirements

A. Casing pipe shall be so constructed as to prevent leakage of any substance from the casing throughout its length, except at ends of casing where ends are left open, or through vent pipes when ends of casing are sealed.

B. Casing pipe and joints shall be capable of withstanding railroad loading.

C. Casing shall be installed so as to prevent the formation of a waterway under the railroad, and with an even bearing throughout its length, and shall slope to one end (except for longitudinal occupancy).

D. The casing pipe and joints shall be made of steel and of leakproof construction.

E. The inside diameter of the casing pipe shall be as shown on the Plans, but shall be such as to allow the carrier pipe to be removed without disturbing the casing or the roadbed. For steel pipe casings, the inside diameter of the casing pipe shall be at least 2 inches (51mm) greater than the largest outside diameter of the carrier pipe joints or couplings, for carrier

pipe less than 6 inches (152 mm) in diameter; at least 4 inches (102 mm) greater for carrier pipe 6 inches (152mm) and over in diameter.

F. For flexible casing pipe, a maximum vertical deflection of the casing pipe of 3 percent of its diameter, plus ½ inch (13mm) clearance shall be provided so that no loads from the roadbed, track, traffic or casing pipe itself are transmitted to the carrier pipe. When insulators are used on the carrier pipe, the inside diameter of the flexible casing pipe shall be at least 2 inches (51 mm) greater than the outside diameter of the carrier pipe for pipe less than 8 inches (203 mm) in diameter; at least 3 ¼ inches (83 mm) greater for pipe 8 inches to 16 inches (203 mm to 406mm), inclusive, in diameter and at least 4 ½ inches (114 mm) greater for pipe 18 inches (457 mm) and over in diameter.

G. Casing pipe under railroad tracks and across COMPANY's right-of-way shall extend the distance shown on the Plans. If not shown on Plans, the casing pipe distance shall be at least the greater of the following distances, as measured at right angle to centerline of track:

1. Across the entire width of the NS right-of-way

2. 3 feet (0.9m) beyond ditch line

3. 2 feet (0.6m) beyond toe of slope

4. A minimum distance of 25 feet (7.6m) from each side of centerline of outside track when casing is sealed at both ends.

5. A minimum distance of 45 feet (12.7m) from centerline of outside track when casing is open at both ends.

6. Beyond theoretical railroad embankment line. This line begins at a point, on existing grade, 14 feet (4.26m) horizontally from centerline track and extends downward on a 2 (H) to 1 (V) slope. (See Plate III) The 14 feet is measured from 19 inches below the base of the rail.

CA-4 Material

A. Casing pipe shall be smooth wall steel pipe and meet the following requirements:

1. Smooth wall steel pipe shall conform to the requirements of ASTM A 139, Grade B (No Hydro) and have a specified minimum yield strength, SMYS, of at least 35,000 psi (241 MPa).

2. The pipe diameter and length shall be as shown on the plans.

3. Steel casing pipe, with a minimum cover of 5 -1/2 ft (1.7m), shall have a minimum wall thickness as shown in Table 1, unless otherwise stated in the project Plans:

Pipe Diameter Nominal Size		Protected Nominal Wall Thickness		Uncoated and Unprotected Nominal Wall Thickness	
Inches	(mm)	Inches	(mm)	Inches	(mm)
10 and under	(254 & under)	0.188	(4.78)	0.188	(4.78)
12 & 14	(305 & 356)	0.188	(4.78)	0.250	(6.35)
16	(406.00)	0.219	(5.54)	0.281	(7.14)
18	(457.00)	0.250	(6.35)	0.312	(7.92)
20 & 22	(508 & 559)	0.281	(7.14)	0.344	(8.74)
24	(610.00)	0.312	(7.92)	0.375	(9.53)
26	(660.00)	0.344	(8.74)	0.406	(10.31)
28	(711.00)	0.375	(9.53)	0.438	(11.07)
30	(762.00)	0.406	(10.31)	0.469	(11.91)
32	(813.00)	0.438	(11.07)	0.500	(12.70)
34 & 36	(864 & 914)	0.469	(11.91)	0.532	(13.49)
38	(965.00)	0.500	(12.70)	0.562	(14.27)
40	(1016.00)	0.531	(13.49)	0.594	(15.09)
42	(1067.00)	0.562	(14.27)	0.625	(15.88)
44 & 46	(1118 & 1168)	0.594	(15.09)	0.657	(16.66)
48	(1219.00)	0.625	(15.88)	0.688	(17.48)
50	(1270.00)	0.656	(16.66)	0.719	(18.26)
52	(1321.00)	0.688	(17.48)	0.750	(19.05)
54	(1372.00)	0.719	(18.26)	0.781	(19.84)
56 & 58	(1422 & 1473)	0.750	(19.05)	0.812	(20.62)
60	(1524.00)	0.781	(19.84)	0.844	(21.44)
62	(1575.00)	0.812	(20.62)	0.875	(22.23)
64	(1626.00)	0.844	(21.44)	0.906	(23.01)
66 & 68	(1676 &1727)	0.875	(22.23)	0.938	(23.83)
70	(1778.00)	0.906	(23.01)	0.969	(24.61)
72	(1829.00)	0.938	(23.83)	1.000	(25.40)

Table 1: Casing Pipe Minimum Wall Thicknesses

B. Coated steel pipe that is bored or jacked into place shall conform to the wall thickness requirements for uncoated steel pipe since the coating may be damaged during installation.

C. Joints between the sections of pipe shall be fully welded around the complete circumference of the pipe.

D. Bedding and select backfill shall conform to Category B dense graded aggregate in accordance with Section GA – Graded Aggregate of the NS Standard Specifications unless stated otherwise by the design ENGINEER or plans.

E. Backfill material shall be loose, fine earth free from stone as approved by the ENGINEER.

F. Casing pipe end seals shall be as follows:

1. Casings for carrier pipes of flammable and hazardous substances shall be suitably sealed to the outside of the carrier pipe. Details of the end seals shall be shown on the Plans.

2. Casings for carrier pipes of non-flammable substances shall have both ends of the casing blocked up in such a way as to prevent the entrance of foreign material, but allowing leakage to pass in the event of a carrier break.

G. Vents for casing pipe shall be as follows:

1. Sealed casings for flammable substances shall be properly vented. Vent pipes shall be of sufficient diameter, but in no case less than two inches (51mm) in diameter, and shall be attached near each end of the casing and project through the ground surface at right-of-way lines or not less than 45 feet (13.7m), measured at right angles from centerline of nearest track.

2. Vent pipes shall extend not less than 4 feet (1.2m) above the ground surface. Top of vent pipe shall have a down-turned elbow, properly screened, or a relief valve. Vents in locations subject to high water shall be extended above the maximum elevation of high water and shall be supported and protected in a manner approved by NS.

3. Vent pipes shall be at least 4 feet (1.2m), vertically, from aerial electric wires or greater as required by the National Electric Safety Code (ANSI C2), the utility authority, or local or State regulations.

4. When the casing pipe is in a public highway, street-type vents shall be installed.

H. Grouting for the jacked installations shall be as follows:

1. For jacked installations a uniform mixture of 1:6 (cement: sand) cement grout shall be placed under pressure through the grout holes to fill any voids which exist between the pipe or linear plate and the undisturbed earth.

I. Non-metallic casing spacers:

1. Casing spacers shall be sized as appropriate for the casing and carrier pipes.

2. Spacers shall be composed of high molecular weight HDPE with at least 3,300 psi tensile strength and 115,000 psi flexural modulus.

3. Max. working temprerature: 225°F

4. Min. working temperature: -180°F

5. Spacers shall be installed and spaced per manufacturer's instructions.

6. For water line applications, shall be NSF approved for potable water.

CA-5 Casing Pipe Installation

A. General

1. Casing pipe installation shall conform to the lines and grades as shown on the plans or as staked in the field by the ENGINEER.

2. The use of water or other liquids to facilitate casing emplacement and spoil removal is prohibited.

3. If during installation an obstruction is encountered which prevents installation of the pipe in accordance with this specification, the pipe shall be abandoned in place and immediately filled with grout. A new installation procedure and revised plans must be submitted to and approved by NS before work can resume.

B. Depth of Installation

1. Utility lines and conduits conveying non-flammable substances shall be as follows:

   a. Casing/carrier pipes placed under COMPANY-owned track(s) shall be not less than 5 ½ feet (1.7m) from base of rail to top of pipe at its closest point, except that under sidings or industry tracks this distance may be 4 ½ feet (1.4m) as approved by NS. On other portion of the right-of-way, where the pipe is not directly beneath any track, the depth from ground surface will be 4 feet (1.2m) or from bottom of ditch to top of pipe shall not be less than 3 feet (0.9m).

   b. Utility lines and conduits not crossing under tracks shall be installed as required in the Project plans and elsewhere in these specifications.

2. Pipelines conveying flammable substances shall be as follows:

   a. Casing pipes under NS track(s) shall be not less than 5 ½ feet (1.7m) from base of rail to top of pipe at its closest point, except that under sidings or industry tracks this distance may be 4 ½ feet (1.4m) as approved by NS. On other portions of the right-of-way, where the pipe is not directly beneath any track, the depth from ground surface will be 4 feet (1.2m) or from bottom of ditch to top of pipe shall not be less than 3 feet (0.9m).

   b. Pipelines laid longitudinally on NS's right-of-way, 50 feet (15.2m) or less from centerline track, shall be buried not less than 6 feet (1.8m) from ground surface to top of pipe. Where the pipeline is laid more than 50 feet (15.2m) from centerline of track, the minimum cover shall be at least 5 feet (1.5m).

C. Casing pipe installation by boring and jacking shall be as follows:

1. The CONTRACTOR shall submit to the ENGINEER a complete plan and schedule for pipe installation two (2) weeks prior to the expected commencement of such work. The submission shall include complete details of the sheeting, shoring and

bracing for the protection of the roadbed, materials and equipment pertinent to the operation. The CONTRACTOR shall not proceed with the pipe installation until he has received acceptance of the plan and schedule from the ENGINEER.

2. The COMPANY shall provide a flagman and a schedule of allowable work periods for the bore and jack operation in accordance with the requirements of Section GI-General Instructions of these Specifications. Work shall stop when a train is passing.

3. If the installation of the pipe is being conducted in an unsafe manner, as determined by the ENGINEER, the CONTRACTOR shall be required to stop work and bulkhead the heading until an alternate procedure is proposed by the CONTRACTOR and accepted by the COMPANY.

4. The installation shall be carried on in such a manner that settlement on the ground surface above the pipe line shall be held to an absolute minimum.

5. The installation of the pipe line shall follow the heading and boring excavation as soon as possible.

6. End of pipe shall remain as close as practical to auger head and the distance shall not exceed 18 inches.

7. The diameter of the excavation shall conform to the outside diameter and the circumference of the pipe as closely as practicable. If voids should develop or if the bored hole diameter is greater than the outside diameter of the pipe by more than 1 inch, the voids shall be pressure grouted.

8. The installation shall be carried on without interruption, insofar as practicable, to prevent the pipe from becoming firmly set in the embankment.

9. Any pipe damaged during the operation shall be removed and replaced by the CONTRACTOR at his expense.

10. The pits or trenches excavated to facilitate the pipe installation shall be backfilled immediately after the installation has been completed and in accordance with these Specifications.

11. Unless otherwise stated on the plans or directed by the ENGINEER, the casing pipe shall remain unplugged with only the carrier pipe through the center.

12. Grouting for jacked installations shall be as follows:

    a. Grouting shall start at the lowest hole in each grout panel and proceed upwards simultaneously on both sides of the pipe.

    b. A threaded plug shall be installed in each grout hole as the grouting is completed at that hole.

c. When grouting tunnel liner plates, grouting shall be kept as close to the heading as possible, using grout stops behind the liner plates if necessary. Grouting shall proceed as directed by NS, but in no event shall more than 6 lineal feet (1.8 m) of tunnel be progressed beyond the grouting.

D. Casing pipe installation by open trench method shall be as follows:

1. Installations beneath the track by open trench methods will be permitted only with the approval of the ENGINEER and the Superintendent of the Division involved. All trackwork will be conducted by COMPANY forces only, and the COMPANY reserves the right to place additional restrictions on the casing pipe work.

2. Backfill material shall be NS Type B Dense Graded Aggregate. Backfill shall be placed in uniform layers and compacted. When vibrator compaction equipment is used in conjunction with other methods of compaction, the compacted depth of a single layer of backfill material shall not exceed 6 inches (6-9 inches loose). When no vibratory compaction equipment is used, the maximum compacted thickness of one layer shall not exceed 3 inches (3-6 inches loose). If a hand tamper is used, it shall weigh not less than 20 pounds and have a tamping face not less than 6 inches x 6 inches.

3. Compactions shall be to a density of not less than 95 percent in accordance with the requirements of AASHTO T 99.

4. Magnetic conduit marking tape shall be placed 10 inches below finished grade and directly above all casing pipe for the full length of the casing pipe.

E. Casing pipe installation on existing utility lines:

1. CONTRACTOR shall be responsible for locating all existing utility lines prior to start of work, and shall notify involved utilities before work begins per local requirements. Unless otherwise handled by the COMPANY, CONTRACTOR is responsible for permits and approvals from impacted utilities.

2. All work on existing utility lines must conform to local and utility requirements. CONTRACTOR is responsible for ensuring that work does not impact existing utility services, and is responsible for any repairs or other work resulting from damage caused by construction activities.

3. Carefully excavate existing utility lines by hand or using small powered equipment so as not to disturb the utility line. The minimum width of the trench and bedding shall be 24 inches greater than the diameter of the casing pipe. Trenches shall be excavated to a sufficient depth to install split casing pipes.

4. CONTRACTOR shall provide temporary trench shoring, temporary supports, or other temporary structures necessary for the successful completion of the work.

5. CONTRACTOR shall install a split casing pipe over the utilities so as not to disturb the existing utilities.

6. Backfill material shall be NS Type B Dense Graded Aggregate. Backfill shall be placed in uniform layers and compacted. When vibrator compaction equipment is used in conjunction with other methods of compaction, the compacted depth of a single layer of backfill material shall not exceed 6 inches (6-9 inches loose). When no vibratory compaction equipment is used, the maximum compacted thickness of one layer shall not exceed 3 inches (3-6 inches loose). If a hand tamper is used, it shall weigh not less than 20 pounds and have a tamping face not less than 6 inches x 6 inches.

7. Compactions shall be to a density of not less than 95 percent in accordance with the requirements of AASHTO T 99.

8. Magnetic conduit marking tape shall be placed 10 inches below finished grade and directly above all casing pipe for the full length of the casing pipe.

CA-6 Measurement and Payment

A. Measurement

1. Casing pipe shall be measured in linear feet along the center of the casing pipe in place.

B. Payment

1. Payment will be made at the Contract Unit bid price per linear foot for casing pipe installed according to installation method (jack and bore, open cut, and split casing). The price shall include materials, labor, equipment and any other incidentals required to complete the Work.

2. No separate payment shall be made for excavation, backfilling, bedding, sheeting, bracing, shoring, traffic control, de-watering, magnetic warning tape, spacers, or removal and repairs to existing streets, sidewalks, curbs, and utilities damaged and/or removed while installing the casing pipe.

END OF SECTION

Section CO – Conduit

CO-1 Description

The Work shall consist of the installation of underground or aboveground conduit systems and enclosures for communications, security, and power systems.

CO-2 General Requirements

A. Related sections:

1. Section EL – Norfolk Southern Electrical Specifications.
2. Section SC – Structural Concrete

B. Codes and standards:

1. OSHA – Occupational Safety and Health Administration
2. NEC – National Electrical Code
3. IEEE – Institute of Electrical and Electronics Engineers
4. UL – Underwriters Laboratories, Inc.
5. ANSI – American National Standards Institute
6. NFPA – National Fire Protection Association
7. ASTM – American Society for Testing and Materials
8. NEMA – National Electrical Manufacturer's Association

C. Definitions:

1. Conduits: In the text of this Section, conduits shall refer to individual "pipes" including associated fittings.
2. Ductbanks: In the text of this Section, ductbanks shall refer to one or more conduits that may be encased in concrete, as shown on the Contract Drawings that run in the same trench.
3. Manhole: In the text of this Seciton, manholes shall refer to precast or cast-in-place vaults or other structures designed for H-20 or greater loading.
4. Handhole: In the text of this Section, handholes shall refer to pull boxes, junction boxes, and other housings designed for H-20 and lesser loadings. Handholes may be constructed of various materials.

5. Conduits installed under this Section shall include conduits used for both power distribution and communications. References to underground electrical work or similar phrases shall be inclusive of both electrical and communications work.

D. Quality Assurance:

1. All materials shall be clearly stamped or tagged as required by the referenced standards.

2. Any materials or workmanship which in the opinion of the ENGINEER does not meet the requirements of the referenced standards, codes, Drawings and these specifications shall be discarded and replaced at the CONTRACTOR's expense.

3. Materials and installation shall conform to the applicable codes and standards.

4. The CONTRACTOR shall carefully examine the Contract Documents, visit the site and become familiar with the local conditions relating to the work. Failure to do so will not relieve the CONTRACTOR from obligations of the Contract.

5. The CONTRACTOR shall notify the ENGINEER of any proposed materials believed to be inadequate, unsuitable, in violation of laws, ordinances, rules or regulations of authorities having jurisdiction.

E. Qualifications:

1. The CONTRACTOR installing the work under this Section shall have a minimum of five (5) years of documented experience specializing in this type of construction.

2. Manufacturers of products specified under this Section shall have a minimum of five (5) years of documented experience in manufacturing these products that meet the requirements of the referenced standards.

F. Coordination:

1. Obtain all available information on underground utilities before starting excavation. If underground utilities interfere with shown location of manholes, bring this to the attention of the ENGINEER soon as possible. The manhole shall be revised or relocated only with the approval of the ENGINEER.

G. Guarantee:

1. The CONTRACTOR shall be responsible for all work under this Section. The CONTRACTOR shall make good, repair or replace at his own costs and expense as may be necessary, any defect which in the opinion of the ENGINEER is the result of imperfections in materials, workmanship or any other act or omission by the CONTRACTOR.

2. Guarantee shall remain in effect for a period of one year after acceptance by the ENGINEER.

H. Delivery and Storage:

1. The CONTRACTOR shall receive, handle, and store all items and materials at the project site.

2. Materials and electrical items shall be so placed that they are protected from damage and deterioration.

I. Submittals:

1. Accurately record actual locations and depths of each enclosure and conduit run.

2. After award of Contract and before submittal of shop drawing schedule, the CONTRACTOR shall submit a complete list of materials proposed for use in the Work. The list shall note the section and paragraph of the specification where the item is required and give the manufacturer's name and trade name or catalog number or other means of identification. Submit the following information in accordance with the General Conditions:

a. Manufacturer's catalog data for all conduit and fittings, end bells, non-metallic cable support racks, manholes, handholes, sealant material, spaces, and manhole and handhole frames and covers.

b. Calculations and Shop Drawings for the manholes and handholes rated for H-20 or higher loading shall be signed and sealed by a Civil Engineer registered in the State. Calculations shall certify that the loading conditions shown on the Contract Drawings have been met.

c. The CONTRACTOR shall submit laboratory trial mix designs in accordance with section SC – Structural Concrete. A submittal is required for each strength and type of concrete specified.

CO-3 Materials – Electrical and Communications Conduit

A. Material usage unless otherwise indicated on Plans:

1. PVC conduit shall be used for all typical underground applications except where galvanized rigid steel conduit (GRC) is indicated on the Plans.

2. Galvanized rigid steel conduit (GRC) shall be used for all aboveground applications and all installation in non-temperature controlled structures.

3. PVC-coated GRC shall be used for all aboveground applications where conduit will be exposed to corrosive or weather-related damage. Applications include elbows and

risers connecting underground conduit to an exterior panel, structure, pedestal, or other electrical equipment.

4. Flexible conduit shall be only used where shown on the plans to provide connections between rigid conduit and machinery or other dynamic equipment. Flexible conduit shall be liquid-tight, neoprene-clad metallic conduit.

5. Underground conduit shall only be concrete-encased in areas indicated on the Plans or as directed by the ENGINEER.

6. Steel casing pipes or concrete encasement shall be used for all track crossings and other areas as indicated on the Plans. Casing pipes shall be installed per section CA – Casing Pipes of this specification.

B. General requirements:

1. Conduit shall be marked at uniform intervals to indicate material.

2. Underground conduit shall be 4" inside diameter for all electrical and communications conduits, except as indicated on the Plans.

3. Conduit spacers:

a. Conduit spacers shall be pre-cast concrete, high impact polystyrene, steel, or a combination of these.

b. Conduit spacers are required for any duct banks carrying any power distribution circuits greater than 480V and for duct banks encased in concrete.

c. Conduit spacers are optional for duct banks carrying communications conduits and power circuits 480V or less, but the Contractor is still responsible for maintaining the required separation between conduits.

4. Closure plug/cap material shall match conduit.

5. Above-ground conduit fittings shall be threaded, metallic, weatherproof, and dust-tight with gasketed covers.

6. Provide threaded conduit fittings in hazardous areas that are UL listed for the appropriate Class and Division of the area. Provide conduit seals, breathers, and drains as required by the NEC.

7. Cable racks shall be heavy duty, molded UL-Listed, and standard yellow fiberglass reinforced nylon with adjustable arms.

C. Galvanized rigid steel conduit (GRC):

1. Galvanized rigid steel conduit and fittings shall be UL 6, heavy wall type, hot dipped galvanized steel after fabrication with zinc-coated threads.

2. Suitable fittings of correct size shall be provided for connecting PVC conduit to rigid steel conduit.

3. Bushings for 1-1/4 inch conduit and larger shall be malleable iron body with 150°C insulating ring. Insulating material shall be locked in place and non-removable.

4. Factory made conduit bends or elbows shall be used whenever possible in making necessary changes in direction.

5. PVC-coated galvanized rigid conduit:

   a. Exterior PVC coating shall be at least 40 mils thick.

   b. Interior urethane coating shall be at least 2 mils thick.

   c. Conduit threads shall be coated with clear urethane over hot galvanized threads.

6. All threads are to be coated with a zinc compound to prevent corrosion.

7. The use of Intermediate Metal Conduit (IMC) or aluminum conduit is not acceptable.

D. Polyvinyl chloride (PVC) conduit:

1. Heavy-wall PVC conduit shall conform to NEMA TC 6 & 8 for direct burial and concrete-encased electrical or communications conduit. PVC conduit fittings shall conform to NEMA TC 9.

2. PVC conduit and all fittings shall conform to ASTM D1785, Schedule 80 PVC, except where otherwise noted.

3. Conduit shall only be concrete-encased where shown on Plans. Schedule 40 PVC may be used only for concrete-encased conduit.

4. Material used for elastomeric seals in the joints shall conform to the requirements of ASTM F 477.

E. Conduit entrance sealing:

1. Provide wall sleeves and expansion fittings for all exterior-to-interior transitions.

2. Provide conduit sealing fittings and sealing cement to conduits exposed to outside at a point just prior to entering the building from the exterior. Provide weep hole just prior to seal to eliminate the buildup of water and other contaminants.

3. Seal conduit penetration and conduit where conduit penetrates a fire-rated structure (See structural drawings as necessary). Utilize self-expanding foam to maintain fire barrier manufactured and approved for this purpose.

4. Conduits penetrating roof shall be flashed with 6" high pitch pockets or equally effective means approved by ENGINEER. Roof penetrations shall not be made except under special written permission from ENGINEER.

F. Conduit terminations inside manholes, handholes, and buildings:

1. Manufactured bell ends of appropriate sizes at each end of conduit. When entering a new building or a new manhole the bell ends for PVC shall be a pre-manufactured system with conduit seals, provisions for roughing into the concrete and water stops.

2. Ground-able steel bushings of appropriate sizes where bell ends are not used. Steel bushings shall be used on all metal conduits. When entering a new building or a new manhole the bell ends for PVC shall be a pre-manufactured system with conduit seals, provisions for roughing into the concrete pour and water stops.

3. When entering an existing building or manhole below grade, the concrete shall be core drilled for the appropriate size conduit and seal. The seal shall be a mechanical interlocking assembly seal of modular synthetic rubber links properly sized to fit the pipe and tightened in place, in accordance with the manufacturer's instruction.

G. Magnetic warning tape:

1. Warning tape shall be 2"-wide with red color.

2. Tape shall have magnetic backing to assist in underground locating.

3. Tape shall be marked "CAUTION – ELECTRIC LINE BURIED" above all electrical conduits and "CAUTION – COMMUNICATIONS LINE BURIED" above all communications conduits.

H. Pull cables:

1. Plastic rope having a minimum tensile strength of 1,200 pounds shall be installed in each empty duct.

2. Leave a minimum of 24 inches of slack at each end of the pull strings.

I. Grounding:

1. Steel grounding bushings shall be grounded to manhole or junction box ground.

2. On steel conduit with end bells, provide a bonding fitting with bonding strap.

3. Connect bonding strap to ground wire in manhole or junction box.

CO-4 Materials – Manholes, Handholes, and Enclosures

A. Material usage

1. Manholes rated for H-20 or greater loading shall be used in all areas where manholes are located in travelways or may be subject to other heavy loads.

2. Polymer concrete handholes rated for Tier 22 loading shall be used in all areas not subject to traffic and protected by barriers.

3. All above-ground boxes and enclosures shall be at least NEMA 3R.

B. General requirements:

1. Electrical manholes and handholes shall be labeled "ELECTRICAL".

2. Communication, signal, and security manholes and handholes shall be labeled “COMMUNICATION”.

C. Precast or cast-in-place manholes:

1. Concrete manholes shall be constructed of structural concrete with a minimum compressive strength of 3000 psi at 28 days. Concrete shall comply with Norfolk Southern Standard Specifications for Materials and Construction, Sections SC-1 to SC-25 (structural concrete) unless otherwise noted on the Plans.

2. Manholes must be designed for a minimum AASHTO H-20 loading unless a higher loading requirement is including on the plan set.

3. Manholes shall opening in top section the same size as required for the necking and shaft openings listed below.

4. Necking and shaft sections shall have the following clear openings, unless otherwise shown on the Plans:

   a. Power Manholes: 40 inch (900 mm) diameter clear opening.

   b. Communication Manholes: 34 inch (760 mm) diameter clear opening.

5. Manholes shall include a 18 inch (300 mm) sump pit and 1 inch (25 mm) ground rod opening in base section, unless otherwise shown on the Plans.

6. Windows for duct entry shall be as shown on the Plans.

7. Provide complete waterproofing top, bottom, and sides.

8. Wall thicknesses shall be at least 6” unless otherwise shown on the Plans.

9. Provide a continuous water stop gasket at all section and slab joints.

D. Manhole accessories:

1. Frames and covers shall be airport-rated, ASTM A48 Class 30B, ductile iron, and machine finished with flat bearing surfaces unless otherwise shown on the Plans.

2. Manhole lid minimum sizes:

   a. Electrical manholes: 40 inch lid

   b. Comm. manholes: 34 inch lid

3. Pulling irons shall be 7/8 inch (22 mm) diameter galvanized steel bar forming a triangle of 9 inches (225 mm) per side when set or, 3/4" eye nut fastened through manhole wall with 3/4" diameter bolt and locknut with 1/4" X 4" square washer.

4. Cable rack inserts or surface-mounted channel and associated hardware shall be a continuous slot stainless steel insert channel with minimum load rating of 2000 pounds (910 kg); 48 inch (1.2 m) length with rigid plastic closure strip or Styrofoam filler. All hardware shall be stainless steel.

5. Cable supports shall be porcelain insulators (split type) with channel clamp, size as needed to match cable size. Heavy duty nonmetallic multi-mount cable support arm - 7”, 10” or 14” arm may be used as necessary.

6. Grounding:

   a. Provide at least one ground rod per manhole, or as required by the NEC, local electrical codes, or on the Plans.

   b. Provide one #4/0 bare stranded copper completely around interior of each manhole. Connect to ground rod.

   c. See Section EL – Electrical Specifications for grounding requirements.

7. Sump Pit:

   a. Minimum 1' 6" diameter by 2' 0" long concrete pipe with sealed concrete bottom.

   b. Sump pit grate shall be ASTM A48, light duty sized to fit sump pit concrete pipe.

E. Handholes

1. Polymer concrete (Quazite or similar) handholes shall be used in areas out of travel ways or protected by bollards. These handholes and covers shall be designed for ANSI 77 – Tier 22 loading.

2. Precast concrete handholes shall be used in areas subject to traffic. These handholes shall be at least 2’x3’ and designed for AASHTO H-20 loading. If vehicle traffic

requires higher loading requirements than H-20, handholes of the appropriate rating shall be installed.

3. Handholes shall be minimum 4 inch square (100 mm) by 2 1/8th inches (54 mm) deep for use with 1 inch (25 mm) conduit and smaller. On conduit systems using 1 1/4 inch (31.75 mm) conduit or larger, pull and junction boxes shall be sized per NEC but not less than 4 11/16 inch square (117 mm).

4. For telecommunication, fiber optic, security, and other low voltage cable installations the NEC box size requirements shall apply. All boxes, used on telecommunication, security, other low voltage and fiber optic systems with conduits of 1 1/4" and larger, shall be sized per the NEC conduit requirements. For determining box size, the conduit is the determining factor not the wire size.

5. Box extensions and adjacent boxes within 48" of each other are not allowed for the purpose of creating more wire capacity.

6. Handholes 6" x 6" or larger size shall be without stamped knock-outs.

7. Wireways shall not be used in lieu of junction boxes.

8. Material shall be fire resistant and shall not burn at a rate greater than 0.3 inches per second per 0.1 inch of thickness when tested in accordance with ASTM D 635.

9. Concrete encasement of handholes shall be as shown on the plans or as directed by the ENGINEER.

F. Outlet boxes:

1. Sheet metal outlet boxes shall be NEMA 3R, waterproof, and outdoor rated.

2. Luminaire and equipment supporting boxes shall be NEMA 3R and rated for weight of equipment supported. Include 3/8" male fixture studs where required.

3. Cast boxes shall be cast ferroalloy, or aluminum type deep type, gasketed cover, threaded hubs.

G. Metal boxes and enclosures:

1. Above-ground enclosures and boxes for outdoor and wet locations shall be at least NEMA 3R, flat-flanged, surface-mounted junction boxes, and UL-listed as rain-tight. Galvanized or aluminum box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

2. Boxes shall be code gauge galvanized steel, screw covers, flanged and spot welded joints and corners.

3. Metal boxes larger than 12" (300 mm) in any dimension shall have a hinged cover or a chain installed between box and cover.

H. Medium voltage termination boxes:

1. Provide boxes constructed out of code gauge type 304 stainless steel and rated minimum NEMA 3R or as required by the Drawings. Provide terminal boxes with a main compartment for termination of medium voltage conductors and an integral auxiliary compartment for termination of space heater connections. Each compartment shall have separate bolted down covers for top entry. Size of the compartments shall be adequate for routing and termination of line side and load side 15kV medium voltage power cables with multiple grounds, ground check, and space heater conductors (conductors sized as shown on the Contract Drawings).

2. Provide terminals boxes with 120VAC operated space heaters sized appropriately for keeping the enclosure free of moisture.

3. Internal components of the terminal boxes shall include a sub-panel base, insulators, phase termination lugs, ground termination lugs, and space heater.

4. Provide a completely assembled, pre-engineered system.

CO-5 Excavation and Backfill

A. Excavation:

1. Excavate trenches for ductbank to adequate width, depth, and proper slope as specified.

2. Trenches shall have a minimum width of 24" plus the diameter of the conduit(s) plus the spacing(s) between the conduits.

3. Trenches shall be deep enough to provide at least 3' minimum cover above the conduit, or as shown on the Plans.

4. No conduit, ductbank or structure shall be installed on frozen ground.

5. Excavated materials shall be disposed of on site, as directed by the ENGINEER.

6. Bottom of trench shall be undisturbed earth. If trench bottom is too low for proper grade, fill to proper level with sand and mechanically compact it.

7. Each excavated section from manhole to manhole and from manhole to building shall be completely excavated and graded before any duct is laid in that section.

8. The CONTRACTOR shall not open more trench in advance of conduit-laying than is necessary to expedite the work.

9. Excavated materials shall not be placed within 5 feet of the edge of the excavation.

10. Shoring shall be required for excavations deeper than 5 feet or side slopes shall be cut back a sufficient amount to prevent slides. The CONTRACTOR shall furnish shoring plan and calculations to the ENGINEER for review and approval 2 weeks prior to the expected start of the shoring installation.

11. The CONTRACTOR shall at all times during construction provide proper and satisfactory means and devices for the removal of all water entering excavations and shall remove water as fast as it may collect in such manner as shall not interfere with the prosecution of the work.

12. The CONTRACTOR shall excavate all material of whatever nature encountered, including rock, to the elevations and dimensions shown on the plans. Rock encountered during excavation shall be removed to a depth of 12" below the grade of elevation of the conduit. The trench should be backfilled with earth, free from stone or hard substances, to the grade elevation.

13. If necessary to remove rock by blasting, the following shall apply:

    a. The Contractor shall hire, at no expense to the Company, a qualified blasting consultant to oversee the use of explosives. The consultant must be independent of the Contractor. The blasting consultant will be empowered to intercede if he concludes that Contractor's blasting operations are endangering the Railway. The Contractor shall prepare a blasting plan, a loading plan indicating the type of initiation system (electrical caps are not allowed), etc.

    b. An evaluation and seismic report for each shot shall be furnished to the ENGINEER. Seismograph shall be placed immediately adjacent to the closest structure to the blasting location, as approved by the ENGINEER. In the event the maximum peak particle velocity of 2 inches per second is exceeded, or unexpected results occur, the CONTRACTOR shall furnish an analysis of the affects on the surrounding conditions, i.e., structures, geology, etc., and the proposed changes to the blasting plan to correct the action, to the ENGINEER for review and approval before continuing blasting operations.

    c. Blasting shall be performed in such a way that rock outside the authorized excavation lines shall not be unduly loosened.

    d. Blasting shall not be done without proper precaution to protect adjacent work, property and persons and then only with the ENGINEER's approval, but such approval shall not relieve the CONTRACTOR from liability. Blasting shall be in accordance with all federal, state and local laws, codes and ordinances. Blasting personnel shall be licensed when required.

    e. The CONTRACTOR shall control blast mechanical effects such as heaving by displacement with the use of steel cables, mats, or other device. No blasting shall be performed without the presence of the ENGINEER or his authorized

representative. In the event the ENGINEER determines blasting to be too hazardous, it shall be discontinued.

B. Backfill:

1. After conduit/casing pipe or structure with bedding and initial backfill has been installed, inspected and approved by the ENGINEER and satisfactorily tested, the trench shall be backfilled using loose, fine earth free from stone as approved by the ENGINEER.

2. The ENGINEER shall approve the use of all on-site material used for backfill. The determination of what is acceptable backfill will be at the sole discretion of the ENGINEER.

3. The backfill for trenches where the inner edge of trench is within two feet or under the edge of pavement, curb and gutter, sidewalk, and within 25 feet of all tracks (including future tracks) shall be made with coarse aggregate trench backfill, as indicated on the Plans.

4. Backfill material shall be placed in uniform layers and compacted. When vibratory compaction equipment is used in conjunction with other methods of compaction, the compacted depth of a single layer of backfill material shall not exceed 6 inches (6-9 inches loose). When no vibratory compaction equipment is used, the maximum compacted thickness of one layer shall not exceed 3 inches (3-6 inches loose). If a hand tamper is used, it shall weigh not less than 20 pounds and have a tamping face not less than 6 inch x 6 inch.

5. Compactions shall be to a density of not less than 95 percent in accordance with the requirements of AASHTO T 99.

6. No depressions along the trench line shall be permitted.

7. Compaction tests on backfill material shall be conducted a minimum of once every 100’ of trench for each lift of material.

C. Pavement removal/restoration in existing paved areas:

1. CONTRACTOR shall remove pavement in accordance with section CG – Clearing and Grubbing. All pavement must be saw cut prior to removal.

2. Any damage to adjacent pavement must be repaired by the CONTRACTOR.

3. After completion of ductbank installation, return all ground and pavement surfaces to original condition or to condition as indicated on the drawings. This includes all sidewalks, curbs, streets, parking areas, lawns, shrubs, etc. covered by other Sections of this Specification (conduit, wire, cable, etc.).

4. The CONTRACTOR shall provide temporary traffic control during construction.

D. Restoration and cleanup:

1. This CONTRACTOR shall remove all mud and debris from manholes after completion. All water shall be removed from manholes. If manholes continue to fill up with water, this CONTRACTOR shall pump them regularly until the source of water has been detected and corrected or until the manhole has been accepted by the ENGINEER.

2. It is the intent of these specifications that the underground raceway system and manholes shall be waterproof with the exception of the manhole covers.

3. As each conduit run is completed, draw a non-flexible testing mandrel not less than 12 inches long with a diameter 1/4 inch less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

4. Submit coordinates and elevations of conduit ends to the ENGINEER and include that information in as-built drawings.

5. As each conduit run is completed, draw a non-flexible testing mandrel not less than 12 inches long with a diameter 1/4 inch less than the inside diameter of the conduit, through the conduit.

6. A stiff bristle brush having the same diameter of the duct shall be pulled through the duct, until duct is clear of particles of earth, sand, and gravel; then immediately install end plugs.

CO-6 Installation – Underground Conduit

A. General requirements:

1. Installation of duct banks shall be in accordance with NFPA 70 and ANSI C2.

2. Conduit shall be concrete-encased only as shown on the Plans or as directed by the ENGINEER. Risers into buildings and equipment shall be coordinated with the placement of the equipment.

3. Each underground conduit joint shall be watertight.

4. Separate signal conduit from power conduit by at least one (1) foot for all parallel runs greater than 10 feet in length.

5. Conduits containing communication wiring must not contain power wiring. All communication wiring must be run in separate conduit from power wiring.

B. Laying conduit:

1. The CONTRACTOR must maintain a constant check of the conduit alignment and trench depth and will be held responsible for any deviations therefrom. Conduit shall be laid in a true and straight alignment, but whenever necessary, deflections may be made in such manner and to such degree as may be approved by the ENGINEER and not exceeding manufacturer's recommendations.

2. Unless otherwise directed, conduit shall be laid with bell ends facing in the direction of laying, and for lines on an appreciable slope, bells shall face upgrade. The trench bottom shall be dug out at each bell end of the conduit to conform to the shape of the bell. Blocking under the conduit shall not be permitted.

3. Installation of the conduit and fittings shall be in strict accordance with the manufacturer's recommendations.

4. Conduit shall have a minimum slope of 4 inches in each 100 feet away from buildings and toward manholes and other necessary drainage points.

5. Run conduit in straight lines except where a change of direction is necessary.

6. During construction, protect partially completed duct lines from the entrance of debris such as mud, sand, and dirt with suitable conduit plugs.

7. Immediately before laying, each section of conduit or fitting shall be thoroughly cleaned inside of all debris, dirt or other accumulated foreign material. It shall be inspected for damage and repairs made where required or removed from the jobsite if deemed irreparable by the ENGINEER. Care shall be taken to keep the interior of already laid conduit clean and free from dirt and other foreign material. At the end of each day's operation CONTRACTOR shall block each open conduit end with caps.

8. Conduit shall be laid with at least 3' minimum cover or as shown on the Plans.

9. Install not more than one 90 degree bend or equivalent between pull points for primary conduit and two 90 degree bends or equivalent for communication conduit, unless otherwise indicated on Plans.

10. Install insulated grounding bushings on steel duct ends.

11. For conduits that are shown on the Plans to be encased in concrete, install spacers as recommended by conduit manufacturer and requirements stated above, but not to exceed a maximum of 6 ft-0 in. on center for PVC conduit and 8 ft-0 in. on center for steel conduit. Bottom spacers shall rest on 8" x 16" x 2" minimum concrete pads to prevent them from sinking into the ground and reducing the bottom concrete cover. Stagger conduit joints in concrete encasement 6 in. minimum horizontally.

12. Conduit shall have a minimum separation of 6", or as shown on the Plans.

13. Jointing procedures shall be in strict accordance with the manufacturer's recommendations.

14. Stagger conduit joints by rows and layers to provide a duct line having the maximum strength.

15. Underground Conduit for Future Extension:

    a. Underground conduit for future extension shall be stubbed out from the manhole or handhole as indicated on the Drawings.

    b. Protect the ends of the conduit by end caps, and coat with cement or other suitable coating.

C. Bedding and initial backfill:

1. The CONTRACTOR shall backfill the trench after the approval of the ENGINEER.

2. Bedding and initial backfill material consisting of sand or crushed stone, as approved by the ENGINEER, shall be placed to a compacted depth of 12" above the top of conduit and at least 6" below the conduit. Compaction shall be to a density of not less than 95 percent in accordance with the requirements of AASHTO T 99. Care shall be taken not to damage the pipe or joints. Sand shall be used where soil free from stone is not available. Aggregate shall be a gravel, crushed stone, or crushed gravel meeting the Norfolk Southern Standard Specifications for Materials and Construction, Sections SC-1 to SC-25 (structural concrete), unless otherwise noted on the design documents.

3. Bedding and initial backfill aggregate shall be mixed uniformly and shall be well graded from coarse to fine within the limits specified.

4. The trench backfill, at a moisture content, which will facilitate compaction, shall be placed along side structures, conduits or ductbanks in layers not exceeding 6 inches in loose depth. The coarse aggregate shall be thoroughly compacted without disturbing or damaging the ductbank, conduit or structure and compacted to 95% maximum dry density by tamping with vibrating compactors.

5. The remainder of the trench shall be backfilled with select material from excavation or borrow, free from large or frozen lumps, clods or stones larger than 4 inches.

6. Magnetic warning tape for electrical conduit shall be placed 12" below finished grade and directly above all conduit and ductbanks for the full length of the conduit.

7. Conduit duct banks shall not be encased or covered with concrete unless indicated on the plans or as directed by the ENGINEER.

8. Compaction tests on backfill material shall be conducted a minimum of once every 100' of trench for each lift of material.

D. Exterior conduit penetrations:

1. Conduit vertical risers and penetrations shall be PVC-coated GRC from the elbow up to the termination.

2. Conduit indicated to be stubbed and capped shall extend 6" above the pavement or pedestal, unless otherwise noted on the Plans.

E. Manhole/handhole conduit terminations:

1. Terminate conduits in end-bells where duct lines enter manholes and handholes.

2. Construct concrete encased duct lines connecting to underground structures to have a flared section adjacent to the manhole to provide shear strength.

3. Construct underground structures to provide for keying the concrete encasement of the duct line into the wall of the structure.

4. Use vibrators when this portion of the encasement is poured to ensure a seal between the encasement and the wall of the structure.

F. Building or structure penetrations:

1. Within five (5) feet of each building wall or manhole wall penetration, install heavy wall galvanized steel conduit within the concrete envelope to provide protection against vertical shearing. This requirement is waived if the reinforcing steel in the ductbank is poured into the wall or the reinforcing steel from the duct-bank is doweled into the wall to provide protection against vertical shearing.

2. When entering an existing building or manhole, core drill existing walls and waterproof using an assembly of rubber links of mechanical seal to the proper size for the pipe and tighten in place, in accordance with the manufacturer's instruction, after the new conduit is installed.

3. Install closure plugs or caps on empty conduits at building entrances and at terminations in equipment pedestals to prevent the entrance of moisture and gases.

CO-7 Concrete Encasement

A. General requirements:

1. Concrete conduit encasement shall be used in place of aggregate bedding and initial backfill only as shown on the Plans or as directed by the ENGINEER.

2. Polymer concrete handholes not cast into a pavement surface shall be encased with 6" of concrete, or as shown on the Plans.

B. Materials:

1. Concrete shall have a minimum compressive strength of 3000 psi at 28 days and comply with Norfolk Southern Standard Specifications for Materials and Construction, Sections SC-1 to SC-25 (structural concrete) unless otherwise noted on the Plans.

2. Portland cement shall meet ASTM C-150, Type 1 specifications.

3. Fine aggregate shall be sand, ASTM C-33. Coarse aggregate shall be well proportioned mixture conforming to size #4 and size #67, Table II, ASTM C-33.

4. Reinforcing steel shall be ASTM A-615, Grade 60 for steel reinforcing bars.

C. Installation:

1. Encase duct with 6 in. minimum of concrete on top, bottom, and sides with top of duct bank troweled to a crown to prevent pooling of water.

2. Excavation and shoring for underground ductbank and structures shall conform to all requirements of the Norfolk Southern Standard Specifications for Materials and Construction, Sections SC-1 to SC-25 (structural concrete) unless otherwise noted on the design documents.

3. Concrete encased conduits shall be held in place by manufacture's standard window-type spacers.

4. Except where rigid galvanized steel conduit is indicated or specified, the conduit shall be PVC Schedule 40.

5. The concrete encasement surrounding the bank shall be rectangular in cross section and shall provide at least 6 inches of concrete cover for conduits.

6. Install forms on sides of ductbank if trench if necessary to prevent cave-ins.

7. Forms shall be mortar-tight, rigid, smooth surface, sufficiently braced, and wet thoroughly (except in freezing weather) or oiled.

8. Clean off foreign matter from reinforcement before placing.

9. Reinforcing bars shall be cold-bent around pins having diameters in accordance with ACI Manual 318-56.

10. Place concrete with the following minimum cover, unless otherwise shown on Plans:

    a. Where concrete is poured against ground: 3"

    b. Where poured in forms but exposed to ground or weather 2"

c. In slabs and walls: 3/4"

d. In beams and columns: 1-1/2"

11. Standard hooks, bends, and laps shall be used.

12. Secured in concrete, metal chairs, or spaces.

13. Nails shall not be driven into forms to support reinforcement.

14. Do not pour concrete under water.

15. Vibrate by an approved mechanical vibrator.

16. Trowel slabs to a smooth finish.

17. Patch all defects and tie rod holes immediately after form removal.

18. Cure concrete a minimum of 5 days. Keep in a moist condition or coat with approved curing compound. Protect from rain and weather conditions when necessary.

19. Cold Weather Requirements:

    a. Provide adequate equipment for heating materials and protecting concrete during freezing or near -freezing weather.

    b. All materials, forms and ground with which concrete will come in contact are to be free from frost.

    c. No calcium chloride or other anti-freezing solution nor any chemical accelerator shall be used in any concrete.

CO-8 Installation – Manholes, Handholes, and Enclosures

A. Handhole installation:

1. Handholes shall be installed in accordance with Plan instructions and manufacturer requirements.

2. Except where approved by the ENGINEER, install conduit prior to setting handholes.

3. CONTRACTOR shall excavate a hole in accordance with this section. The excavation shall provide at least 12” horizontal clearance around each side of the enclosure, and be at least 8” deeper than the proposed enclosure.

4. The CONTRACTOR shall install and compact a 6” sand or aggregate base layer prior to installing the handhole.

5. Handholes shall be set plumb, level, and flush with the finished surface.

6. Support enclosures independent of conduit.

7. Carefully backfill in accordance with this section. Make necessary adjustments during backfill to maintain handhole alignment.

8. Where enclosures are not set into new concrete or asphalt pavement, the handhole shall be encased in 6" of concrete.

B. Precast concrete manhole installation:

1. Install and seal pre-cast sections in accordance with manufacturer's instructions.

2. Use gasketed pre-cast neck and shaft sections to bring manhole entrance to proper elevation.

3. Install manholes plumb.

4. Set the top of each manhole to finished elevation.

5. Manholes must be designed for a minimum AASHTO H-20 loading unless a higher loading requirement is including on the plan set.

C. Installation of manhole accessories:

1. Insert and seal sump pit into manhole floor. Put one sump pit in each manhole except, where a primary and a communication manhole are side-by-side, place one sump pit in the communication manhole and core a 4" hole at the floor line from the primary manhole to the communication manhole.

2. Grounding:

a. Install ground rod with top protruding 4 inches (100 mm) above manhole floor.

3. Ground Wires:

a. Install the wires around the inside perimeter of the manholes and anchor them to the walls.

b. Connect the wires to the ground rod by exothermic welding process to form solid metal joints.

c. Bond the wires to any splice shield wires, ground wires, cable racks, sump frames and other metal items in the manholes.

d. All separate ground wires accompanying circuits shall be grounded in each manhole passed through.

4. Cable Support System:

a. In each manhole, after installation is complete, install porcelain cable clamps or heavy duty nonmetallic cable racks on all of the walls for not less than one set of cables, and as many additional racks as required for the cables which are being installed for this contract.

b. Cable support intervals shall be approximately 4 feet (1.2 m).

c. Provide adequate slack in the cables.

d. Strap cable to insulators with plastic tie wraps.

e. All phase and ground cables in each circuit shall be kept together and contained on/in the cable supports. No phase cable shall be run separate from the other two phases and ground.

5. Waterproof exterior surfaces, joints, and interruptions of manholes after concrete has cured 5 days.

6. Install cable pulling irons opposite each duct entry window.

D. Coordination of Box Locations Inside Structures:

1. Provide electrical boxes as shown on Plans and as required for splices, taps, wire pulling, equipment connections, and code compliance.

2. Electrical box locations shown on Plans are approximate unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

3. No outlet shall be located where it will be obstructed by other equipment, piping, lockers, benches, counters, etc.

4. Boxes shall not be fastened to metal roof deck.

5. It shall be the CONTRACTOR's responsibility to study drawings pertaining to other trades, to discuss location of outlets with workmen installing other piping and equipment and to fit all electrical outlets to job conditions.

6. In case of any question or argument over the location of an outlet, the CONTRACTOR shall refer the matter to the ENGINEER and install outlet as instructed by the ENGINEER.

7. The proper location of each outlet is considered a part of this contract and no additional compensation will be paid to the CONTRACTOR for moving outlets which were improperly located.

8. Locate and install boxes to allow access to them. Where installation is inaccessible, coordinate locations and provide 18 inch (450 mm) by 24 inch (600 mm) access doors.

9. Locate and install to maintain headroom and to present a neat appearance.

10. Install boxes to preserve fire resistance rating of partitions and other elements, using approved materials and methods.

E. Outlet Box Installation:

1. Do not install boxes back-to-back in walls. Provide minimum 6 inch (150 mm) separation, except provide minimum 24 inch (600 mm) separation in acoustic-rated walls.

2. Recessed power outlet boxes (1/4" maximum) in masonry, concrete or tile construction shall be masonry type, minimum 4 inch square. Device covers shall be square-cut except rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted. Coordinate masonry cutting to achieve neat openings for boxes.

3. Recessed (1/4" maximum) low voltage outlet boxes in masonry, concrete or tile construction shall be masonry type, minimum 4 11/16 inch square. Device covers shall be square-cut except rounded corner plaster rings are allowed in drywall applications. Angle cut plaster rings are not permitted. Coordinate masonry cutting to achieve neat openings for boxes.

4. Provide knockout closures for unused openings.

5. Support boxes independently of conduit except for cast boxes that are connected to two rigid metal conduits, both supported within 12 inches (300 mm) of box.

6. Use multiple-gang boxes where more than one device are mounted together; do not use sectional boxes. Provide non-metallic barriers to separate wiring of different voltage systems.

7. Install boxes in walls without damaging wall insulation.

8. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

9. Ceiling outlets shall be 4 inch (100 mm) octagon or 4 inch square, minimum 2-1/8 inch (54 mm) deep except that concrete boxes and plates will be approved where applicable. Position outlets to locate luminaires as shown on reflected ceiling plans. All ceiling outlets shall be equipped with 3/8 inch (10 mm) fixture studs.

10. In inaccessible ceiling areas, position outlets and junction boxes within 6 inches (150 mm) of recessed luminaire, to be accessible through luminaire ceiling opening.

11. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning to allow for surface finish thickness. Use

stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

12. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

13. Provide cast ferroalloy or aluminum outlet boxes in exterior and wet locations, outdoor rated NEMA 3R in all other areas.

14. Surface wall outlets shall be 4 inch (100 mm) square with raised covers for one and two gang requirements.

15. For three gang or larger requirements, use gang boxes with non-overlapping covers.

F. Medium voltage termination box installation:

1. Rigidly support boxes from building structure, structural steel, or concrete foundations, indepen-dent of the conduit system, as shown on contract drawings. Locate all boxes so as to be easily accessible. Provide adequate clearance above box for removal of top cover.

2. Furnish and install cable glands for routing of the line and load side cables into the terminal box. Cable glands shall be rated for NEMA 4 use.

3. Close all unused and open knockouts with plugs of the proper size and type. Appropriate materials shall be used to ensure enclosures are returned to their original NEMA rating.

4. Identify the nominal voltage levels contained within the enclosure by attaching a plastic nameplate to the cover of the box. Identifications shall be as approved by the ENGINEER.

CO-9 Installation – Above-Ground Conduit

A. Install sufficient size conduits such that the required number of conductors can be installed without injury to the insulation or excessive strain to the conductor. Size all conduits for circuits as required. Maximum allowable conduit fill shall be in accordance with NEC Article 344 22 and Table 1, Chapter 9. Size conduits in excess of the requirements of NEC where pulling distances or number of bends necessitate a more liberal conduit fill factor. Provide all exposed conduits of minimum size of 3/4 inch. Provide conduit reducers, transition pieces, and other hardware as necessary where required. Install all work in hazardous locations per NEC utilizing UL Listed equipment and UL Listed sealing compound for said equipment.

B. Secure conduit connections to sheet steel enclosures such as cabinets, panelboards, pullboxes, junction boxes, wireways, etc. with hubs (instead of locknuts) with insulated bushings inside the enclosure. Assure ground continuity by use of bonding wire(s) properly sized and installed to bond all conduit entering and leaving the enclosure by means of ground connector clamps or ground¬ing conduit bushing. Bond an equipment

ground conductor to the enclosure sized for the largest conduit entering or leaving the enclosure or the highest circuit ampacity of the conductors entering the enclosure per Table 250 66 NEC, whichever is greater. Bond all flexible conduits with a properly sized grounding conductor.

C. Provide conduit expansion fittings with external bonding jumpers wherever conduits cross structure expansion joints. Provide conduit expansion fittings with external bonding jumpers wherever a transition occurs from one structure to another to allow for structure movement and settlement. Provide expansion joints for runs of conduit subject to varying ambient temperature, able to accommodate expansion of 1" per 100 feet of conduit.

D. Make up all exterior rigid conduit joints and connecions using zinc primer and conductive sealing compound to insure a watertight joint and prevent steel conduit threads from rusting.

E. Provide a weep hole in each outside conduit run at lowest box or fitting and provide entrance to electrical equipment or device from below, or provide drip loop ahead of device to prohibit condensation build up from entering electrical equipment or devices.

F. Provide flexible liquid tight metallic conduit with external bonding jumper wherever a transition occurs from one structure to another to allow for structure movement and settlement.

G. Provide standard 'LB' covers in 1 inch and smaller boxes. Provide 'LED' dome covers in 1-1/4 inch and larger devices. Covers and bodies to be made of Form 7 malleable iron, aluminum is not acceptable.

H. Provide conduit bends reasonably free of flat surfaces, kinks, or dents. Use a bending machine to make all bends in conduits that are 3/4 inch diameter and larger.

I. Hold conduit securely in place by approved hangers and fasteners of appropriate design and dimensions for the particular application. Acceptable supporting and clamping material to exposed conduit includes malleable iron one hole clamps with clamp backs. Do not use perforated steel tape, wire hangers, stamped steel straps or similar materials. Use standard supporting methods such as unistrut or powerstrut type products, or threaded rods for support of conduits. Use only clamps that will not allow building up of material and dust. All methods of supporting conduit must be approved by ENGINEER prior to installation.

J. Mount all conduits such that a 1.5" minimum offset is maintained from all walls and horizontal surfaces.

K. Precautions must be taken to inhibit filings from entering control panels and terminal boxes while installing conduits.

L. Install conduits so those conduits do not inhibit personnel and machinery movement; i.e. locate conduits on the outside of walkways and aisles. Insure that conduits do not cover

or in any way reduce intentional openings. Locate conduits a minimum of one (1) foot above finished floor.

M. Provide adequate support for all conduit runs. Spacing between conduit clamps or other supports shall be per NEC guidelines for each type of raceway. In all raceway installations, support distance shall be short enough to prevent sagging in horizontal conduit runs.

N. Output wiring from variable frequency drives shall be run in separate conduits. Output wiring from variable frequency drives in cable tray shall be run in MC type cable with 3-ground system.

O. Exercise necessary precaution to prevent accumulation of water, dirt, or concrete in conduits during execution of electrical work. Conduit in which water or foreign material has been permitted to accumulate shall be thoroughly cleaned or replaced where such accumulations cannot be removed. Spare conduits should remain capped. Plug conduits that are terminated underground for future connection with an approved material prior to installation.

P. Identify and clearly mark all conduits leaving the switchgear, motor control centers, panelboards, control panels, and I/O panels as to their destination.

Q. LB fittings are not permitted anywhere in a conduit run containing fiber optic cabling. Pull boxes shall be utilized as an alternative to LB fittings in order to maintain the proper bend radius (based upon manufacturer's specifications) for the fiber optic cable.

CO-10 Interior Cable Management

A. Use of cable management systems and supports:

1. Cable trays or wireways shall only be used for interior installations.

2. Galvanized rigid conduit shall be used for all standard interior applications in accordance with this section.

B. Cable trays:

1. ENGINEER must approve all cable tray routing prior to purchase or installation.

2. Furnish and install pre-galvanized steel straight ladder sections supported in 12 foot spans with 100 pounds-per-foot load capability, 1.5 safety factor, minimum 5" side rail height, 9" rung spacing, minimum 12" wide cable tray as shown on the contract drawings and as specified herein.

3. Furnish and install all fittings, slice plates, expansion joints, hardware, and supports where required to install a complete tray system. Hardware to be zinc plated steel. Expansion splice plates shall be installed per VE-1 and NEC and minimally at 65 foot intervals in straight runs of outdoor cable tray. Expansion guide clamps, glide strips,

and 1000 Amp copper bonding jumpers shall be used in conjunction with the expansion splice plates to allow for proper expansion and contraction of the cable tray system.

4. Cable tray shall be built and tested to NEMA VE-1 Standards and shall comply with the National Electrical Code as to construction and installation of cable tray systems.

5. All areas where the galvanizing is damaged or breached (such as cutting, drilling, etc.) on the cable tray shall be re-finished per NEMA VE-2 standards in order to maintain corrosion protection.

6. Cable tray must be UL classified and labeled for use as an equipment ground conductor.

7. Cable tray sections shall be bonded to #4/0 AWG grounding conductor routed through entire cable tray.

8. Installation requirements:

    a. Install cable tray along cable tray supports in accordance with manufacturer requirements.

    b. Provide adequate supports for cable tray and exposed runs of MC-HL cable in accordance with latest edition of NEC. Minimum spacing between supports of exposed runs shall be at 6 foot intervals.

    c. Install cable tray and supports as detailed on the contract drawings and provide #4/0 AWG bare copper ground conductor. Bond ground conductor to cable tray as required per the latest revision of the NEC.

    d. Install all cable tray in accordance with NEC and NEMA VE-2 requirements.

    e. Post cable tray with: "Warning: Not to be used as a walkway, ladder or support for personnel. To be used only as a mechanical support for cable."

C. Wireways:

1. Cabling to enclosed wireways is to be routed in conduit with appropriate fittings for transition to duct from conduit. Covers shall not be obstructed.

2. Wireways, where indicated on the drawings, shall be of the sizes indicated on the drawings unless, upon closer examination, the number of cables necessitates a larger size. Ample room shall be provided for installing and training the conductors.

3. All wireways shall be supported in accordance with manufacturer's recommendations independent of conduits or cables entering them.

4. Individual conductors of circuits, cable types, or like cables of systems shall be tied together with suitable cabling twine or wire ties.

5. Conductors and cables in troughs shall be tagged at both ends with permanent markers.

CO-11 Measurement and Payment

A. Measurement

1. Measurement for underground conduit shall be made per linear foot by size and type of conduit installed.

2. Measurement for above-ground conduit, cableways, and wireways shall be made per linear foot by size and type installed.

3. Measurement for underground ductbanks shall be made per linear foot by cross-section of ductbank installed.

4. Measurement for manholes and handholes shall be made per each by size and material.

B. Payment:

1. Payment for underground conduit shall be made at the contract unit price per linear foot by size and type of conduit installed.

2. Payment for above-ground conduit, cableways, and wireways shall be made at the contract unit price per linear foot by size and type installed.

3. Payment for underground ductbanks shall be made at the contract unit price per linear foot by cross-section of ductbank installed.

4. Payment for manholes and handholes be made at the contract unit price per each by size and type of manhole or handhole installed.

5. All payments shall include furnishing, installing, transporting, excavation, labor, concrete, incidental materials, grounding, testing, pull wires, warning tape, spacers, and all other work for a complete installation.

6. No separate payment shall be made for underground conduit, ductbanks, above-ground conduit, handholes, and other appurtenances when the work is included as part of a structure, building, panel, electrical equipment, enclosure, or other appurtenance.

END OF SECTION

Section SS – Sanitary Sewer

SS-1 Description

The Work shall consist of the construction of a gravity or force sanitary sewer in accordance with these Specifications, as shown on the plans, or as directed by the ENGINEER.

SS-2 General

A. The CONTRACTOR shall be responsible for obtaining all required permits, and complying with all local, state and federal guidelines and codes. The COMPANY shall be responsible for obtaining all of the necessary permits for the sewer line installation.

B. The CONTRACTOR shall be responsible for determining the exact location of the existing buried sanitary sewer line and/or any other utilities that may conflict with the installation. The CONTRACTOR shall endeavor to install the sanitary sewer line without interrupting service and/or damaging other utilities. However, should interrupted service and/or damage to other utilities occur during the installation, the CONTRACTOR shall be responsible for quickly restoring service and repairing damage at no cost to the COMPANY. The COMPANY shall have its communication and signal lines located and the CONTRACTOR shall protect the lines during construction.

C. The CONTRACTOR shall restore existing pavement sections, sidewalks and curbs disturbed during the installation of the sanitary sewer. Disturbed surfaces shall be restored as is or as shown on the plans. Asphalt pavement, concrete for concrete pavement, sidewalks and curbs, and crushed stone shall meet the requirements of Section AP - Asphalt Pavement, Section CP - Concrete Pavement and Section GA - Graded Aggregate of these Specifications, respectively.

D. The flow of all sewers, drains, streets, gutters and watercourses encountered shall be provided for by, and at, the CONTRACTOR's own expense. Whenever such water courses and drains are disturbed or destroyed during the prosecution of the work, they shall be restored by and at the expense of the CONTRACTOR to a condition satisfactory to the ENGINEER.

E. All publicly owned existing overhead, surface or subsurface structures, together with all appurtenances and service connections, except those otherwise provided for herein, encountered or affected in any way during the construction of the Work under this contract, shall be maintained in service at all times unless other arrangements, satisfactory to the authority responsible for their operation, are made with such authority.

F. Where connections are to be made to existing sewers, the CONTRACTOR shall make suitable provisions for maintaining the flow in the existing sewer until the connection is completed.

G. Casing pipe shall be installed per Section CA – Casing Pipe.

SS-3 Material

A. Polyvinyl chloride (PVC) plastic sewer pipe and fittings shall meet the following requirements unless otherwise specified:

1. Pipe shall be Type PSM SDR-35 PVC and conform to the requirements of ASTM D 3034.

2. Pipe shall not be installed in lengths greater than 20 feet.

3. PVC fittings shall conform to ASTM D 3034.

4. All joints shall be push-on joints. The assembly of joints shall be in accordance with the requirements of ASTM D 3212. Material used for elastomeric seals in the joints shall conform to the requirements of ASTM F 477.

B. Ductile iron pipe and fittings shall meet the following requirements unless otherwise specified:

1. Ductile iron pipe shall be designed to meet the requirements of AWWA C150.

2. Pipe shall be manufactured in accordance with the requirements of AWWA C151.

3. Pipe diameter, rated working pressure, standard thickness class and the laying condition shall be as shown on the plans.

4. Pipe shall have an outside coating of bitumastic enamel or approved equal.

5. Fittings shall be standard pattern, ductile iron with an outside coating of bitumastic enamel or approved equal, and conform to the requirements of AWWA C110.

6. Joints shall be the push-on type conforming to the requirements of AWWA C111.

C. Pipe bedding material shall conform to the requirements of ASTM D 2321, Class II embedment material.

D. Precast concrete manholes shall be constructed as shown on the plans and conform to the requirements of ASTM C 478. Concrete shall have a minimum 28 day compressive strength of 4,000 psi. The air entrainment in the concrete shall be 6 percent plus or minus 2 percent. Pipe openings shall be formed, drilled or neatly cut and be approved by the ENGINEER.

E. Concrete for cast-in-place manhole bases shall have a minimum 28 day compressive strength of 3,000 psi and conform to the requirements of Section SC - Structural Concrete of these Specifications. Air entrainment shall not be required.

F. Mortar shall be one part Portland cement and 2 parts sand by volume mixed with sufficient water to form a workable stiff mixture.

G. Ductile iron grates and lids shall be as shown on the plans and conform to the requirements of ASTM A536. All castings shall be true to pattern and free from cracks, gas holes, flaws and excessive shrinkage. Surfaces shall be free from burnt on sand and be reasonably smooth.

H. Materials shall be installed in accordance with the manufacturers' recommendations.

I. Backfill and bedding materials shall be as shown on Plans or required by the local utility authority. Native soil may not be used for initial backfill material.

J. Grade-level spill containers for sanitary dump stations shall meet the following requirements:

1. Composite threaded base with polyethylene bucket and drain valve.

2. Cast iron mounting ring with fiber reinforced cover.

3. Sanitary riser pipe shall be 6" PVC with a 4" camlock fitting.

SS-4 Installation - Open Trench Method

A. Sanitary sewer installation shall conform to the lines and grades as shown on the plans or as staked in the field by the ENGINEER

B. For installation in excavated trenches, the width of the trench and bedding shall be 24 inches greater than the outside diameter of the pipe.

C. Excavated materials shall not be placed within 5 feet of the edge of the excavation.

D. Shoring shall be required for excavations deeper than 5 feet or side slopes shall be cut back a sufficient amount to prevent slides. The CONTRACTOR shall furnish shoring plan and calculations to the ENGINEER for review and approval 2 weeks prior to the expected start of the shoring installation.

E. The CONTRACTOR shall at all times during construction provide proper and satisfactory means and devices for the removal of all water entering excavations and shall remove water as fast as it may collect in such manner as shall not interfere with the prosecution of the work.

F. Rock encountered during excavation shall be removed to a depth of 12 inches below the grade of elevation of the sewer line. The trench should be backfilled with approved material to the grade elevation.

G. Prior to laying pipe, the CONTRACTOR shall place bedding material to grade along the length of pipe to be installed. Material shall be compacted to a density of not less than 95 percent in accordance with the requirements of AASHTO T 99.

H. All open ends of pipe shall be plugged to prevent dirt, mud and other debris from entering the pipe.

I. The laying of pipe in finished trenches shall be commenced at the lowest point so that the spigot ends point in the direction of flow. All pipes shall be laid with ends abutting and true to line and grade.

J. Where necessary with bell end pipe, suitable bell-holes shall be excavated in the bedding material for the bell of each pipe so that the weight of the pipe will not be supported by the bells only.

K. Pipes shall be fitted and matched so that when laid they shall form a conduit with a smooth and uniform invert.

L. All possible care shall be used when shoving the pipe together so that joints will not be unnecessarily large. Pipe ends shall be carefully cleaned before laying pipe.

M. Gaskets shall be installed in accordance with the manufacturer's recommendations.

N. The CONTRACTOR shall install cleanouts at locations shown on the plans. Cleanouts shall be the same material as the sewer line. Diameter of the pipe shall be as shown on the plans. The elbow for the cleanout shall have a slow sweep in the same direction as the flow. The CONTRACTOR shall pour a concrete collar around the cleanout and install a 60 pound meter frame as shown on the plans.

O. The CONTRACTOR shall place a bedding cutoff trench dam of impervious soil across and along the trench at a point 20 to 30 feet upstream from the main sewer wye, tee, or saddle to retard and resist the movement of groundwater through the trench bedding and backfill materials. The trench dams shall be 3 feet in thickness, as measured along the sewer centerline, and shall be constructed against the undisturbed trench sides from the bottom of the subgrade to 1 foot over the top of the pipe.

P. Bedding material shall be placed under the lower haunch of the pipe, compacted and then additional material placed to the spring line of the pipe and compacted.

Q. Initial backfill of bedding material shall be placed to a compacted depth of 6 inches above the top of the pipe. Care shall be taken not to damage the pipe or joints.

R. Remainder of backfill material shall be placed in accordance with the requirements of subsection SS-8.

S. All connections with existing manholes shall be made after the manholes have been cleaned in a thorough, first class, neat and workmanlike manner.

T. Pipe shall not protrude into the inside face of manholes, as measured along the horizontal center of the pipe unless the pipe is placed through the entire diameter of the manhole.

U. Rubber water stop joints or mortared rubber gaskets poured in place shall be used for watertightness between the pipe and manhole.

V. Casing pipes for sanitary sewer shall be installed at the locations shown on the plans in accordance with the requirements of subsection CA – Casing Pipe.

SS-5 Manhole Installation

A. Precast concrete manhole installation shall conform to the lines and grades as shown on the plans or as staked in the field by the ENGINEER.

B. Manholes shall be installed as follows:

1. Excavation shall be in accordance with Section GR - Grading of these Specifications.

2. Bedding material shall be placed, spread and compacted a minimum of 4 inches under the structures. Bedding shall be placed and compacted around the manholes to the mid-point of the pipe branches.

3. The CONTRACTOR shall install a precast base or a cast-in-place base. Cast-in-place bases shall be constructed in accordance with the requirements of Section SC - Structural Concrete of these Specifications with the exception that forms shall not be required.

4. Precast sections shall be placed and aligned to provide vertical sides and vertical alignment of the ladder rungs. The completed manhole shall be rigid, true to dimensions and watertight.

5. Pipe sections shall be flush on the inside of the structure wall. Masonry shall fit neatly and tightly around the pipe. Rubber water stop joints or mortared rubber gaskets poured in place shall be used for water tightness between the pipe and manhole.

6. When new holes are required in a manhole, they shall be core drilled or star drilled in a circle of the required diameter and then knocked out. In no instance shall new holes be sledge hammered out.

7. All joints between precast elements in the manholes shall be made with an approved bitumastic and/or an approved rubber gasket in accordance with the requirements of ASTM C 443.

8. All lift holes and all joints between precast elements in manholes shall be thoroughly wetted and then be completely filled with mortar, smoothed and painted with mortar , both inside and out, to ensure water tightness.

9. Channels and inverts shall be made to conform accurately to the sewer characteristics and grades and shall be brought together smoothly with well-rounded junctions.

10. Castings shall be set accurately to the finished elevation so that no subsequent adjustment shall be necessary or unless otherwise specified by the ENGINEER.

11. When adjusting rings are used to set the castings to grade, they shall be pointed up and made watertight by using ½ inch preformed sealant or approved equal in the center of the ring with the required mortar paint inside and out.

12. Where the installation is in an unpaved street or alley, not less than 12 inches of adjusting ring shall be provided between the top of the cone or slab and the underside of the casting for adjustment of the casting to finished grade.

13. Castings placed on concrete surface shall be set in full mortar beds.

14. Excavation shall be backfilled in accordance with subsection SS-7.

C. Any damage to the precast concrete structure caused by improper handling or backfilling shall be repaired by the CONTRACTOR at no cost to the COMPANY.

SS-6 Inspection and Testing

A. Pipes and manholes shall be inspected and approved by the ENGINEER before any backfill is placed.

B. Any pipe or manhole found to not comply with these Specifications or with the drawings shall be repaired or replaced by the CONTRACTOR at no cost to the COMPANY.

C. Infiltration and/or exfiltration leakage tests shall be performed on gravity sewers after all installed pipe and manholes have been cleaned and obstructions removed and prior to backfilling. Tests shall be in accordance with local codes and regulations.

D. Force mains shall be pressure tested in accordance with local codes and regulations prior to backfilling.

E. The CONTRACTOR shall be responsible for any repairs or adjustments to the sanitary sewer which may be necessary to make the sanitary sewer conform to the required leakage limits.

F. All leakage tests shall be conducted under the supervison of the ENGINEER.

SS-7 Backfill

A. After pipes and manholes have been installed, inspected and approved by the ENGINEER, the trench/excavation shall be backfilled using suitable materials excavated from the trench or structure excavation, from the roadbed excavation, or borrow materials. Backfill material shall be approved by the ENGINEER.

B. Backfill material shall be placed in uniform layers and compacted. When vibratory compaction equipment is used in conjunction with other methods of compaction, the

compacted depth of a single layer of bedding material shall not exceed 6 inches (6-9 inches loose). When no vibratory compaction equipment is used, the maximum compacted thickness of one layer shall not exceed 3 inches (3-6 inches loose). If a hand tamper is used, it shall weigh not less than 20 pounds and have a tamping face not less than 6" x 6".

C. Compactions shall be to a density of not less than 95 percent in accordance with AASHTO T 99.

D. All pipes, after being backfilled, shall be protected by a minimum of 2 feet cover of fill before heavy equipment is permitted to cross during the construction of the roadbed.

E. Backfill and bedding materials shall be as shown on Plans or required by the local utility authority. Native soil may not be used for initial backfill material.

SS-8 Measurement and Payment

A. Measurement

1. Sanitary sewer installed shall be measured in linear feet in place.

2. Manholes shall be measured by the number of each installed.

3. Cleanouts shall be measured by the number installed.

4. Sanitary dump stations shall be measured by the number of dump stations installed.

5. There shall be no separate measurement for trenching, structure excavation, bedding material, or backfill material.

B. Payment

1. Payment for sanitary sewer lines will be made at the Contract unit bid price per linear foot for the type (gravity or force) of sanitary sewer installed, which price shall include materials, labor, equipment and any other incidentals required to complete the Work.

2. Payment for manholes will be made at the Contract unit bid price per each manhole installed, which price shall include materials, labor, equipment, and any other incidentals required to complete the work.

3. Payment for cleanouts will be made at the Contract unit bid price per each cleanout installed, which price shall include materials, labor, equipment, and any other incidentals required to complete the work.

4. Payment for dump station will be made at the Contract unit bid price per each dump station installed, which price shall include materials, labor, equipment, and any other incidentals required to complete the work. Payment shall include the concrete

containment areas, aggregate base, cleanout with open grate cover, dry well, riser pipes and bends, and any reducers required for connection to main sanitary pipe.

5. No separate payment will be made for the following:

   a. Maintaining drainage and service in existing structures.

   b. Excavation, backfill, or furnishing and placing bedding material.

   c. Sheeting, bracing and shoring.

   d. Furnishing and maintaining traffic barricades and signs.

   e. Tie-in to existing sanitary sewers.

   f. Repairs to existing streets and utilities damaged and/or removed while installing the sanitary sewer.

END OF SECTION

Section WL – Water Line

WL-1 Description

The Work shall consist of the construction of a water line in accordance with these Specifications, as shown on the plans, or as directed by the ENGINEER.

WL-2 General

A. The CONTRACTOR shall be responsible for obtaining and complying with all local, state and federal guidelines and codes. COMPANY shall be responsible for obtaining all of the necessary permits for the water line installation.

B. The CONTRACTOR shall be responsible for determining the exact location of the existing buried sewer lines, water lines and/or any other utilities that may conflict with the installation. The CONTRACTOR shall endeavor to install the water line without interrupting service and/or damaging other utilities. In the event of interrupted service and/or damage to other utilities occur during the installation, the CONTRACTOR shall be responsible for quickly restoring service and repairing damage at no cost to the COMPANY. The COMPANY shall have its communication and signal lines located and the CONTRACTOR shall protect the lines during construction.

C. The CONTRACTOR shall restore existing pavement sections, sidewalks and curbs disturbed during the installation of the water line. Disturbed surfaces shall be restored as is or as shown on the plans. Asphalt pavement, concrete for concrete pavement, sidewalks and curbs, and crushed stone shall meet the requirements of Section AP - Asphalt Pavement, Section CP - Concrete Pavement and Section GA - Graded Aggregate of these Specifications, respectively.

D. The flow of all drains, streets, gutters and watercourses encountered shall be provided for by, and at, the CONTRACTOR's own expense. Whenever such water courses and drains are disturbed or destroyed during the prosecution of the Work, they shall be restored by and at the expense of the CONTRACTOR to a condition satisfactory to the ENGINEER.

E. All publicly owned existing overhead, surface or subsurface structures, together with all appurtenances and service connections, except those otherwise provided for herein, encountered or affected in any way during the construction of the Work under this contract, shall be maintained in service at all times unless other arrangements, satisfactory to the authority responsible for their operation, are made with such authority.

F. The CONTRACTOR shall submit to the ENGINEER 3 copies of all material drawings showing sufficient manufacturer's specifications. Material drawings are required for all pipe, pipe fittings, valves and other fixtures specified. The CONTRACTOR's use of materials shall be subject to rejection and replacement at the CONTRACTOR's expense if material drawings are not submitted and approved by the ENGINEER prior to the use of the materials.

G. For casing pipes, see section CA – Casing Pipes.

WL-3 Material

A. Polyvinyl chloride (PVC) plastic pipe and fittings shall meet the following requirements unless otherwise specified:

1. Pipe shall conform to the requirements of ASTM D 1784, Class 12454-B, for PVC compounds and the requirements of AWWA C900 with cast iron pipe O.D., for PVC pipe. Pipe diameter shall be as shown on the plans.

2. Joints shall be push-on type and conform to the requirements of ASTM D 3139. Material used for elastomeric seals in the joints shall conform to the requirements of ASTM F 477.

3. Pipe shall not be installed in lengths greater than 20 feet.

4. Approved plastic fittings or approved ductile iron fittings made for PVC pipe shall be used.

B. Ductile iron pipe and fittings shall meet the following requirements unless otherwise specified:

1. Pipe shall conform to the requirements of AWWA C151. Pipe diameter, rated working pressure, standard thickness class and laying condition shall be as shown on the plans.

2. Pipe shall have a nominal length of 16 feet, 18 feet, or 20 feet.

3. Pipe and fittings shall have a bituminous coated cement lining conforming to the requirements of AWWA C104 and have an outside coating of bitumastic enamel or approved equal.

4. Joints shall be of the push-on type or the mechanical type both conforming to the requirements of AWWA C111. Mechanical joints must be used within 25 feet of any track, as measured perpendicular to the track.

5. Rubber gaskets, ductile or cast iron glands and steel bolt shall meet the requirements of AWWA C111.

C. Copper tubing and fittings shall meet the following requirements unless otherwise specified:

1. Tubing shall conform to the requirements of ASTM B 88, Types K and L seamless water tube, annealed temper.

2. Fittings shall be wrought-copper, solder-joint type and conform to the requirements of ASTM B 16.22.

3. Brazing filler materials shall be AWS A.5.8, BcuP (copper-phosphorus) series.

4. Solder shall conform to the requirements of ASTM B 32.

D. Valves shall meet the following requirements:

1. Non-rising stem gate valves 3 inches and larger shall conform to the requirements of AWWA C509 and have a cast iron or ductile iron body and bonnet. Valves shall have a cast iron double disc, bronze disc and seat rings, bronze stem, stem nut and mechanical joint ends. Valves shall have a design minimum working pressure as shown on the plans.

2. Resilient seated non-rising stem gate valves 3 inches and larger shall conform to the requirements of AWWA C509 and have a cast iron or ductile iron body and bonnet, bronze stem, stem nut, and mechanical joint ends. Valves shall have a design minimum working pressure as shown on the plans.

3. Butterfly valves shall be tight closing rubber seated type and conform to the requirements of AWWA C504. Bodies shall be either cast iron conforming to the requirements of ASTM A126, Class B, or ASTM A 48, Class 40, or ductile iron conforming to the requirements of ASTM A536, Grade 65-45-12. Valves shall be designed to seat at 90 degrees to the pipe axis. Valves shall have integrally cast mechanical joint ends. Operators shall be a square operating nut and open counterclockwise with the same number of turns as a gate valve. Valves and appurtenances, including operator, shall be suitable for buried and submerged service.

4. Combination air-release valves shall be as specified in the project Plans or required by the local water authority. All piping and isolation valves shall be brass except for the air outlet from the valve which shall be brass or copper tubing. Relief valves shall be placed in a valve box.

5. Backflow preventers shall be as specified in the project Plans or required by the local water authority.

6. Tapping valves shall be iron body, double disc or resilient seated gate valves with non-rising stems conforming to the requirements of AWWA C500 and C509. Valves shall be compatible with tapping machine.

7. Small-diameter ball valves 2” and smaller shall be consist of brass components with PTFE coating. Valves shall be manufactured in accordance with ANSI/AWWA C800 and components shall conform to ASTM B62 and ASTM B584.

E. Tapping sleeve shall be cast iron or ductile iron 2-piece bolted with flanged outlet for new branch connection. Sleeve shall have mechanical joint ends with rubber gaskets or sealing rings in sleeve body. Sleeve shall mate with size and type pipe material being tapped. Outlet flanges shall be size required for branch connection. Tapping sleeve shall comply with the requirements of the local water authority.

F. Valve boxes shall be as shown on the plans and be placed over all valves unless directed otherwise by the ENGINEER. "WATER" shall be cast in the lid of the valve boxes.

G. Fire hydrants shall be as shown on the plans, conform to the requirements of the local code and meet the requirements of AWWA C502.

H. Meter box shall be as shown on the plans.

I. Backflow preventer vault shall be as shown on the plans.

J. Concrete shall have a minimum 28 day compressive strength of 3,000 psi and conform to the requirements of Section SC - Structural Concrete of these Specifications.

K. Pipe bedding material shall conform to the requirements of ASTM D 2321, Class II embedment material.

L. Ductile iron grates and lids shall be as shown on the plans and conform to the requirements of ASTM A536. All castings shall be true to pattern and free from checks, gas holes, flaws and excessive shrinkage. Surfaces shall be free from burnt on sand and be reasonably smooth.

M. Mechanical joints shall conform to ANSI/AWWA C153 and NFPA requirements.

N. Above-ground heated enclosures shall conform to the following:

1. Enclosures shall be formed from aluminum sheeting and certified to ASSE 1060.

2. Unless otherwise shown on plans, heating system shall be capable of protecting piping and appurtenances to -30°F outside temperature. Heating elements shall be sized to maintain equipment at 40°F inside the enclosure in accordance with NFPA requirements..

3. The heating elements, thermostat, and all other electrical equipment shall be UL listed. The power source shall be installed inside the enclosure by the Contractor with a GFCI receptacle or circuit.

O. Polyethylene pipe encasements shall conform to ANS/AWWA C105/A21.5.

P. Yard hydrant shall conform to the following requirements, or as shown in Plans:

1. Yard hydrant shall have 1" NPT inlet with manual shut off valve and galvanized steel pipe construction.

2. Yard hydrant shall be freezeless with tapped drain hole.

3. \Hydrant should include a variable-flow plunger.

4. Yard hydrant shall include a bury depth at least 1' below the frost line or as shown on the Plans.

5. Maximum working pressure: 125 psi

6. Maximum temperature: 120°F

Q. Materials shall be installed in accordance with the manufacturers' recommendations.

R. Backfill and bedding materials shall be as shown on Plans or required by the local utility authority. Native soil may not be used for initial backfill material.

S. Hose reel cabinets shall meet the following requirements:

1. The CONTRACTOR shall furnish and install temperature-controlled hose reel cabinets at the locations shown on the plans.

2. Cabinet shall be UL-listed and meet all local electrical and water service requirements.

3. The CONTRACTOR shall install a concrete base in accordance with cabinet manufacturer requirements.

4. Cabinet construction:

a. Cabinet shall be approximately 48" x 32" x 40" with insulation, containment wall, access door, electrical panel, interior light, and interior 120VAC receptacle.

b. Cabinet shall be constructed of an outer shell of 12-ga. steel with an inner shell of 16-ga. steel and 1-1/2" insulation on the top, bottom, and all four sides.

c. Cabinet shall include an access door and two hinged services doors on each side.

d. Base shall include 1" drain fitting, 1" fluid fitting, and ¾" electrical conduit fitting.

e. Cabinet shall be fully grounded in accordance with the electrical specifications, manufacturer requirements, and applicable local requirements.

5. Heater:

a. The cabinet shall be outfitted with a heater and thermostat to maintain 90°F temperature.

b. The heater shall be 1,500W, 120 VAC.

c. Cabinet shall include a thermometer to indicate cabinet temperature mounted on the outside of the cabinet.

6. Hose reel:

a. 444-11 with 100' of ¾" water hose

b. Electric rewind motor: 120 VAC, ¼ HP, 4.6 A

7. Inlet assembly: ¾" flexible hole with a ¾" union ball valve

8. Outlet assembly: ¾" gate valve with water nozzle

T. Combination eyewash/shower stations shall meet the following requirements, unless otherwise noted on plans:

1. Station shall be a combination eyewash/facewash station with an integrated shower that is compliant with ANSI Z358.1-2009.

2. Frost-proof construction with 4' minimum bury depth, unless otherwise noted on plans.

3. Eye/facewash and shower shall be independently operated by separate push handles.

4. Galvanized steel construction with stainless steel showerhead and eyewash bowl. Station shall be coated safety yellow.

5. Eye/facewash shall include stainless steel dust cover, and provide a safe, uninterruptible water flow of at least 3.0 gpm at 30 psi..

6. Shower shall provide a safe, uninterruptible water flow of at least 30 gpm at 30 psi.

7. Station shall include an isolation valve.

WL-4 Installation

A. Water line installation shall conform to the lines and grades as shown on the plans or as staked in the field by the ENGINEER.

B. For installation in excavated trenches, the minimum width of the trench and bedding shall be 16 inches for pipe less than 4 inches in diameter and for pipe 4 inches or greater in diameter, the minimum trench width shall be the diameter of the pipe plus 24 inches. Trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill over the top of the pipe as shown on the plans. Greater pipe cover depths may be necessary on existing pipe, conduits, drains, drainage structures, or other obstructions encountered at normal pipe grades.

C. Excavated materials shall not be placed within 5 feet of the edge of the excavation.

D. Shoring shall be required for excavations deeper than 5 feet or side slopes shall be cut back a sufficient amount to prevent slides. The CONTRACTOR shall furnish shoring plan and calculations to the ENGINEER for review and approval 2 weeks prior to the expected start of the shoring installation. Shoring shall comply with all applicable safety standards.

E. The CONTRACTOR shall at all times during construction provide proper and satisfactory means and devices for the removal of all water entering excavations and shall remove water as fast as it may collect in such manner as shall not interfere with the prosecution of the work.

F. CONTRACTOR shall excavate all material of whatever nature encountered, including rock, to the elevations and dimensions shown on the plans. Rock encountered during excavation shall be removed to a depth of 12 inches below the grade of elevation of the water line. The trench should be backfilled with approved material to the grade elevation.

G. CONTRACTOR shall not open more trench in advance of pipe laying than is necessary to expedite the work.

H. Prior to laying of the pipe, the CONTRACTOR shall place 4 inches of bedding material to grade along the length of pipe to be installed. Material shall be compacted to a minimum of 95 percent Standard Proctor Density. The bedding shall be dug out at each bell end of the pipe to conform to the shape of the bell. Blocking under the pipe shall be prohibited.

I. The CONTRACTOR must maintain a constant check of the pipe alignment and trench depth and will be held responsible for any deviations there from. Pipe shall be laid in a true and straight alignment, but whenever necessary, deflections may be made in such manner and to such degree as may be approved by the ENGINEER and not exceeding manufacturer's recommendations.

J. Unless otherwise directed, pipe shall be laid with bell ends facing in the direction of laying, and for lines on an appreciable slope, bells shall face upgrade.

K. Installation of the pipe and fittings shall be in strict accordance with the manufacturer's recommendations. Ductile iron pipe shall be cut with either a saw or abrasive wheel. The cutting of the pipe with a torch shall not be permitted.

L. Immediately before laying, each section of pipe or fitting shall be thoroughly cleaned inside of all debris, dirt or other accumulated foreign material. It shall be inspected for damage to the coating or pipe material and repairs made where required or removed from the jobsite if deemed irreparable by the ENGINEER. Care shall be taken to keep the interior of already laid pipe clean and free from dirt and other foreign material.

M. Jointing procedures shall be in strict accordance with the manufacturer's recommendations.

N. Concrete thrust blocks with anchor rods shall be provided as shown on the plans. Care shall be taken to keep concrete off all flange bolts. Anchor rods shall be tightly wrapped around pipe with ends bent and embedded in the concrete.

O. Gate and butterfly valves shall be installed in accordance with the requirements of AWWA C600.

P. Backflow preventers and vaults, water meter, air-release valves, tapping valves, tapping sleeves and valve boxes shall be installed in accordance with the manufacturer's recommendations and local codes.

Q. Fire hydrants shall be installed immediately after the pipe is laid at locations shown on the plans. Hydrants shall be plumb. The CONTRACTOR shall install a thrust block against the hydrant as shown on the plans for a bend. The areas around the hydrant and hydrant valve shall be thoroughly compacted to prevent settlement of these areas.

R. Yard hydrant shall be installed immediately after the pipe is laid at locations shown on the plans. Hydrants shall be plumb. The CONTRACTOR shall install a thrust block against the hydrant as shown on the plans for a bend. The areas around the hydrant and hydrant valve shall be thoroughly compacted to prevent settlement of these areas.

S. Initial backfill of bedding material shall be placed to a compacted depth of 12 inches above the top of pipe. Compaction shall be to a density of not less than 95 percent in accordance with the requirements of AASHTO T 99. Care shall be taken not to damage the pipe or joints.

T. Remainder of backfill material shall be placed in accordance with subsection WL-7.

U. Casing pipes shall be installed in accordance with section CA – Casing Pipes.

V. Hose reel cabinets shall be installed in accondance with manufacturer's recommendations, and must be securely fastened to pedestals or foundations. Concrete pedestals shall be constructed in accordance with the plans, manufacturer requirements, and section SC – Structural Concrete. Grounding and electrical work for the cabinet shall be performed in accordance with the plans, manufacturer requirements, NEC requirements, and the electrical sections of this specification.

W. Combination eye/facewash and shower stations shall be installed in accordance with manufacturer's recommendations. All pipe connections must be security before installing concrete footings or thrust blocks, and the station shall be installed plumb. The CONTRACTOR shall install thrust blocks against the station riser bends as shown on the plans or recommended by the manufacturer. The areas around the eye/facewash stations shall be fully compacted to prevent settlement.

WL-5 Testing

A. The CONTRACTOR shall test the completed water line for the required water pressures and for water in accordance with the local codes.

B. The CONTRACTOR shall furnish all the apparatus, materials and labor required to perform the test.

C. The CONTRACTOR shall be required to perform a separate pressure test on each section of pipe between gate valves. Work shall not be progressed beyond 2 untested sections.

D. Testing shall be performed simultaneously with the installation. The CONTRACTOR shall suspend trenching and pipe laying operations anytime where, if continued, there would be more untested line than 2,500 feet. The CONTRACTOR may be required, at his own expense, to insert temporary plugs or valves to meet this requirement.

E. A "wet tap" for service connections shall be made before line testing is completed. All service connections and fire hydrants between 2 valves limiting the test shall be uncovered and be subjected to the same pressure as the water line. No leakage at these connections shall be allowed.

F. All concrete thrust blocks shall be in place before applying the test.

G. Should the water line fail to obtain and hold the required pressures and/or leakage exceeds the minimum set forth, the CONTRACTOR shall take such steps as are necessary to bring it within the required limits before the line can be approved by the ENGINEER and backfilling operations completed.

H. Hose reel cabinets shall be tested in accordance with manufacturer requirements. Electrical testing shall be performed in accordance with the electrical specifications.

I. Combination eye/facewash and shower stations shall be tested in accordance with ANSI Z358.1 and manufacturer recommendations. Testing shall be performed after construction has been completed in the vicinity of the shower station.

WL-6 Backfill

A. After the water line and appurtenances have been installed, inspected and approved by the ENGINEER and satisfactorily tested, the trench shall be backfilled using loose, fine earth free from stone as approved by the ENGINEER.

B. Backfill material shall be placed in uniform layers and compacted. When vibratory compaction equipment is used in conjunction with other methods of compaction, the compacted depth of a single layer of backfill material shall not exceed 6 inches (6-9 inches loose). When no vibratory compaction equipment is used, the maximum compacted thickness of one layer shall not exceed 3 inches (3-6 inches loose). If a hand tamper is used, it shall weigh not less than 20 pounds and have a tamping face not less than 6" by 6".

C. Compactions shall be to a density of not less than 95 percent in accordance with the requirements of AASHTO T 99.

D. No depressions along the trench line shall be permitted.

E. All pipes, after being backfilled, shall be protected by a minimum of 2 feet cover of fill before heavy equipment is permitted to cross during the construction of the roadbed.

WL-7 Disinfection of Water Line

A. The water line should be tapped on top at the far end and an air cock installed of sufficient size to release any air that may be entrapped in the line when filled (a hydrant installed at the end of the line shall serve the same purpose as an air cock). The air cock should be open when the line is initially filled with water to allow for air to escape.

B. After testing, the line shall be flushed thoroughly to remove all dirt and debris which has been collected in the water line. The valve at the end of the line should be closed and the valve between the new water line and the existing water system opened slightly to allow water to enter the new line slowly.

C. Line shall be disinfected in accordance with the local codes.

D. Water samples shall be taken from various points along the line for bacterial and chemical analysis in accordance with the local codes. If satisfactory results are obtained, the line may be placed in service. If analysis shows the results to be unsatisfactory. The CONTRACTOR shall repeat the disinfectant process until such time satisfactory results are obtained.

E. Backfill and bedding materials shall be as shown on Plans or required by the local utility authority. Native soil may not be used for initial backfill material.

WL-8 Measurement and Payment

A. Measurement

1. Polyvinyl chloride pipe shall be measured in linear feet along the center line of polyvinyl chloride pipe in place, including the lengths of all pipes, fittings and valves.

2. Ductile iron pipe installed shall be measured in linear feet along the center line of ductile iron pipe in place, including the lengths of all pipes, fittings and valves.

3. Copper tubing installed shall be measured in linear feet along the center line of copper tubing in place, including the lengths of all pipes, fittings and valves.

4. Fire hydrants shall be measured by the number of each installed. No separate measurement shall be made for branch piping, fittings and couplings.

5. Valves, valve boxes or vaults shall be measured by the number of each size and type of valve, including valve boxes, vaults, bases, lids and covers, installed.

6. Meters and meter boxes shall be measured by the number of each meter installed.

7. Yard hydrants shall be measured by the number of each installed.

8. Hose reel cabinets shall be measured by the number of cabinets installed.

9. Combination eye/facewash and shower stations and other safety appurtenances shall be measured by the number of stations installed by type.

B. Payment

1. Payment for pipe will be made at the Contract unit bid price per linear foot for the type of pipe installed for the water line, which price shall include materials, labor and equipment.

2. Payment for fire hydrants will be made at the Contract unit bid price per each fire hydrant installed, which price shall include materials, labor and equipment.

3. Payment for valves and valve boxes or vaults will be made at the Contract unit bid price per each type and size of valve installed, which price shall include materials, including the valve box or vault, labor and equipment.

4. Payment for water meter and meter box will be made at the Contract unit bid price for each water meter installed, which price shall include materials, with the exception of the water meter which is to be furnished by the COMPANY, labor and equipment.

5. Payment for yard hydrants will be made at the Contract unit bid price per each fire hydrant installed, which price shall include materials, labor and equipment.

6. Payment for hose reel cabinets will be made at the Contract unit bid price per each cabinet installed, which price shall include materials, labor and equipment.

7. Payment for combination eye/facewash and shower stations will be made at the Contract unit bid price per each station installed, which price shall include materials, labor, and equipment.

8. No separate payment will be made for the following:

   a. Excavation and backfilling.

   b. Furnishing and placing bedding material.

   c. Sheeting, bracing and shoring.

   d. Furnishing and maintaining traffic barricades and signs.

   e. Trackwork required.

   f. Tapping into existing water line.

   g. Repairs or adjustments required to comply with pressure testing limits.

   h. Testing and disinfection.

i. Repairs to existing streets, sidewalks, curbs and utilities damaged and/or removed while installing the water line.

j. Branch piping, fittings and couplings used to connect appurtenances to main lines.

k. Thrust blocks.

END OF SECTION

Division VIII: Specialty Equipment

Section DO – Damaged Container Dock Equipment

Section MPT – Maintenance Pad Tanks

Section MPR – Maintenance Pad Equipment Racks

Section OWS – Oil-Water Separator

Section DO – Damaged Container Dock Equipment

DO-1 Description

The Work shall consist of the CONTRACTOR furnishing all labor, material, equipment and incidentals necessary for a complete installation of the damaged container dock equipment as shown on the contract drawings and required in this specification.

DO-2 General

A. Standard dock equipment covered by this section shall include:

1. Dock levelers, including control equipment.

2. Prefabricated metal stairs, constructed in accordance with section MF – Metal Fabrication.

3. Handrails, constructed in accordance with section MF – Metal Fabrication.

B. Quality assurance:

1. Equipment shall be produced by a manufacturer of established reputation with a minimum of five years experience supplying specified equipment.

2. Where provisions of pertinent codes and standards conflict with this Specification, the more stringent provisions shall govern.

3. Dock levelers shall conform to the requirements of ANSI MH14.1 – 1987

4. Dock Level Qualifications:

   a. Manufacturer to be associated with the Loading Dock Equipment Manufacturers.

   b. Manufacturers welding procedure compliant with AWS D1.1 98 specifications.

   c. Level shall be installed by an installer specialized in performing the Work of this Section with minimum 5 years experience.

C. Provide the following submittals for approval by the ENGINEER for each item of equipment to be installed:

1. Product Data: Submit for materials, fabrication and installation for each type of equipment specified, including catalog cuts of anchors, hardware, fastenings and accessories. Submit manufacturer's product data showing capacities and capabilities and instructions, operating and maintenance instructions for each product.

a. Restrict submitted material to pertinent data. For instance, do not include manufacturer's complete catalog when pertinent information is contained on a single page.

2. Shop Drawings: For each type of equipment not explained in manufacturer's product and data sheets, showing layout, sizes, heights, profiles, clearances, recesses and anchorages. Particular attention is to be paid to items that require advance coordination with work, such as the placement of reinforcement and electrical equipment.

3. Assurance/Control Submittals:

a. Certificates: Manufacturer's certificate that Products meet or exceed specified requirements.

b. Qualification Documentation: Submit documentation of experience indicating compliance with specified qualification requirements.

DO-3 Product Handling

A. Deliver equipment in manufacturer's containers, appropriately packaged and/or crated for protection during domestic shipment and storage in humid and/or dusty conditions.

B. Indelibly label all containers, including those contained in others, on outside with item description(s) per title and Equipment Identifier of this specification.

C. Provide equipment and materials specified complete in one shipment for each equipment item. Split or partial shipments are not permissible.

DO-4 Warranty

A. Warrant work specified herein for one year from substantial completion against defects in materials, functions and workmanship.

B. Warranty shall include materials and labor necessary to correct defects.

C. Defects shall include, but not limited to rough or substandard operation; loose, damaged or missing parts; and abnormal deterioration of finish.

D. All parts shall be readily available locally in the United States.

E. Dock Leveler: Standard ten-year structural and five-year on power pack. One-year parts and labor warranty from date of shipment.

DO-5 Material

A. Specifications are based on equipment herein by manufacturer's name and model to establish acceptable standards of quality, features, performance and construction. Subject

to compliance with requirements, equipment produced by other manufacturers, including those listed in this specification, may be considered equal.

B. Hydraulic Dock Levelers shall meet the following requirements:

1. The dock seal shall have the following characteristics:

   a. Recessed, pit installed dock leveler.

   b. Electro-hydraulic operated.

2. Nominal sizes:

   a. Width: 7’

   b. Length: 7’

3. Function

   a. Vertical Travel: Working range of 12” above and 12” below dock level.

   b. Automatic Vertical Compensation: Unit provides float of 12” above and 12” below dock level.

   c. Automatic Lateral Compensation: Provides maintained side-to-side deck tilt of up to 4”to compensate for canted truck beds.

   d. Lip Operation: Hydraulically powered lip. Lip will yield under impact of incoming truck and will automatically drop pendant upon truck’s departure. The length of the lip extension shall not be less than 16” from the ramp edge.

4. Operation

   a. Hydraulic Operating System: Easy to operate, quiet and smooth cycling. Electro-hydraulic raising and hydraulic lowering of the dock ramp controlled from a remote single or multi (pending model selected) pushbutton station. Includes means of lowering the dock ramp below platform level. The loaded ramp’s free fall is limited to not over 3” by a hydraulic velocity fuse. Unit shall come complete with a 1 HP, totally enclosed fan cooled (TEFC) motor and equipped with overload protection. Power pack mounted underneath the deck ramp.

   b. Remote PB Control Station: Provide a single operation push button control station with constant pressure “I” (UP) and thermal “R” (RESET) button. Control station shall be NEMA4 (water and dust tight) rated.

5. Rated Capacity

   a. Welding procedure compliant with AWS D1.1 98 specifications. All units rated in compliance with ANSI MH30.1. UL approved electrical components.

b. Dynamic gross weight capacity of 35,000 lbs.

c. Structural deck support to include minimum six each high tensile solid steel I-beam members.

6. Safety Devices

a. Full operation range metal toe guard protection.

b. Hydraulic velocity fuse "fall safe" to limit free fall up to 3".

c. Cross traffic support – lip engaged in saddles.

d. Corner safety stops.

e. Telescopic v-grooved maintenance strut, integral to unit.

f. Chamfered lip.

7. Finish color

a. Toe guard painted safety yellow as specified by ANSI 535.1. Remainder of representative unit painted Pantone 300 blue, metalized zinc, or color selected by ENGINEER from or equal manufacturers' standard colors. High visibility OSHA safety striping on stationary side toe guards.

8. Accessories

a. Night Locks.

b. Two model laminated bumpers with the following dimensions: 14" W x 10" H x 4.5" D (356 mm x 254 mm x 115 mm).

c. Side and rear nylon brush weather seals.

d. Hot-dip galvanized or zinc metalized finish.

e. Clean pit frame.

f. 480V supply voltage or as shown on electrical plans.

g. Vehicle restraint to keep trailer securely stationed at the loading dock.

C. Prefab steel stairs – Prefab steel stairs shall be OSHA type structural steel stairways and meet the following:

a. Designed for attachment to concrete loading dock at the height and location shown on the Plans.

b. Meets OSHA requirements. Code-approved handrail, risers and handrail extensions.

c. 11" (280 mm) deep extra heavy duty bar grating stair treads that will not sag or dish.

d. 36" (915 mm) wide treads, 40" (1016 mm) overall stair width.

e. 10" (254 mm) structural channel stringers.

f. Factory welded .

g. Constructed from heavy gauge steel.

h. One piece stringer and handrail assemblies improve rigidity and ease of installation.

i. Fire proof construction.

j. Galvanized finish (B.S. 729) for maximum corrosion protection.

k. Pre-manufactured and shipped knocked down. All components and hardware included.

l. Refer to Section MF – Metal Fabrication for steel fabrication requirements.

D. Handrails – Handrails and railing shall meet the following requirements:

1. Handrails and railing shall be end products of one manufacturer to achieve standardization for appearance, maintenance and replacement.

2. Fittings:

a. Fabricated from material similar to railings.

b. Elbow, flanges, sleeves, brackets and similar items shall be bolted or welded when indicated.

c. Connections shall be continuous diameter for smooth appearance and to permit continuous sliding of hands.

3. Extensions:

a. Fittings for open handrail extensions shall be of welded construction and welded to vertical posts to comply with OSHA loading requirements.

4. Chains shall be 3/16 in. minimum stainless steel link chain with spring actuated stainless steel clasp capable of withstanding 250 lb horizontal force.

5. Mechanical fasteners shall be constructed of stainless steel.

6. Field-verify dimensions before fabrication.

7. Fabrication requirements:

    a. Form connections and changes in railing direction by using prefabricated fittings or radius bends.

    b. Remove burns from exposed cut edges.

    c. Locate intermediate rails of railing between top rail and finish floor as indicated on Drawings.

    d. Close pipe ends using prefabricated fittings.

    e. Space posts as shown on Drawings. Where spacing is not shown, space posts not more than 5 ft center-to-center.

    f. For posts set on walkways, provide base flange or side mounting base plate.

    g. Fabricate joints which will be exposed to weather to exclude water or provide weep holes where water may accumulate.

    h. Finished paint shall be OSHA safety yellow.

8. Handrail materials:

    a. Aluminum alloy and temper recommended by aluminum producer and finisher type of use and finish indicated, and with not less than strength and durability properties of alloy and temper designated below for each aluminum form required.

        i. Extruded Structural Pipe and Tube: ASTM B429, alloy 6063-T6, Schedule 40, 1-1/2 inch IPS (1.90 in. OD, 0.145 in. wall thickness)

        ii. Plate and Sheet: ASTM B209 (ASTM B209M), alloy 6061-T6

        iii. Die and Hard Forgings: ASTM B247 (ASTM B247M), alloy 6061-T6

    b. Toe plates shall be1/4 in. thick by 4 inch high (7 mm x 102 mm) flat aluminum, alloy 6063-T6, or “S” type aluminum plate, with clamp-on type connection.

    c. Finish shall be a mechanical, nonspecular, architectural Class I, 0.7 mil coating complying with AAMA 607.1 on exposed surfaces. Handrail finish should be safety yellow.

DC-6 Installation

A. General

1. Install dock leveler, steel stairs, handrails and railing in accordance with plans, shop drawings and manufacturer's instructions.

2. Upon completion of work, surfaces shall be free of tool marks, scratches, blemishes and stains.

3. Touch-up damage to painted finishes.

4. Wipe and clean off any oil, grease and solvents and make ready for use.

B. Dock Leveler

1. Positioning: Place equipment in accordance with any noted special positioning requirements.

2. Anchorage: Attach equipment as directed by the manufacturer. Installation fasteners shall be installed to avoid scratching or damaging adjacent surfaces.

3. Anchor dock leveler flush and steel stairs securely, flush with dock. Set square and level.

4. Weld back of dock leveler to pit frame. Touch-up welds with matching paint.

5. All work with other trades, in particular the mounting channel requirements for the dock leveler, must be coordinated to ensure adequate support is provided for installation. Adjust the installation plan as required based on this coordination. Indentify to the Engineer beforehand any needed adjustments.

6. Adjust installed dock leveler for smooth and balanced operation.

C. Handrails and railings

1. Coat base flanges to be in contact with 2 coats of epoxy paint.

2. Set posts plumb and aligned in each direction to within 1/8 inch in 12 feet.

3. Set rails horizontal or parallel to rake of steps to within 1/8 inch in 12 feet.

4. Expansion Joints (Exterior Only)

   a. General:

      i. Provide at intervals of not more than 30 ft on-center.

      ii. Locate joints within 12 inches of posts.

iii. Design for temperature differential of 75°.

b. Railings:

i. Provide slip joint with interval sleeve extending 2 in. beyond each side of joint.

c. Toe Plate

i. Provide slip joint in accordance with Drawings.

5. Install safety chains. The number of chains shall match the number of horizontal rails. Chain drape shall not exceed 3 inches.

6. Provide toe board or plate. Install with bottom not more than 1/4 in. above walking surface. Match expansion joint location to railing joint location.

DO-7 Measurement and Payment

A. Measurement

1. Dock leveler furnished and installed as shown on the plans and in conformance with these specifications, shall be measured per each unit installed.

2. No separate measurement shall be made for the metal stairs and handrails.

B. Payment

1. Payment for the dock leveler listed in this specification and shown on the contract drawings shall be made at the Contract Unit Price per each of all types indicated in bid item complete in place and accepted. Payment shall constitute full compensation for furnishing, installing and placing all materials including excavation and backfill for the dock leveler and all labor, equipment, tools, electrical/control wiring, and incidentals necessary to complete the work as specified and required for a fully operational system/device.

2. Payment for metal stairs and handrails shall be included in the lump-sum cost for the reload dock.

END OF SECTION

Section MPT – Maintenance Pad Tanks

MPT-1 Description

Work involves furnishing and installing complete fuel or oil tank systems for intermodal maintenance pads. Tank systems shall include spill containment, alarm systems, and dispenser systems as a complete task. Tanks will be used in the maintenance of intermodal facility equipment, including cranes, sideloaders, hostlers, yard trucks, and other vehicles.

MPT-2 General Requirements

A. Tanks shall have the following capacities unless otherwise noted on Plans:

1. Diesel fuel: 3,000 gal.
2. Gasoline: 300 gal.
3. Waste oil: 300 gal.
4. 40W motor oil: 300 gal.
5. Transmission oil: 300 gal.
6. Anti-freeze: 300 gal.
7. Hydraulic fluid: 500 gal.

B. CONTRACTOR shall submit Manufacturer cut sheets, manuals, and specifications for the ENGINEER's approval prior to ordering. Submittals shall include materials, features, operating and maintenance manuals, lists of repair parts, capacities, dimensions, certifications, and other relevant information.

C. Tanks shall comply with NFPA 30 "Flammable and Combustible Liquids Code" and NFPA 30A "Automotive and Marine Service Station Code"

D. Work shall include all product piping, electrical, and control/safety wiring work for the tanks, monitoring systems, and dispenser systems.

E. Tank, dike, and other steel parts shall be fabricated from new structural-grade carbon steel. All carbon steel shall meet ASTM A35 or ASTM A569.

F. All fittings shall be protected with plastic thread protector to prevent damage during shipping and installation.

G. Assembly shall be furnished with removable steel rainshields designed to prevent precipitation and debris from entering the diked area. The rainshield shall allow for easy visual inspection of the dike interior and allow the diked area to be naturally ventilated.

H. Primary tank shall be provided with a fill containment sump designed to contain spills of up to 3 gallons in a tank-top reservoir. A 1" (min.) overflow pipe shall divert spills in excess of 3 gallons into the containment dike.

I. Tank assembly shall be provided with stairs, landing, and handrails meeting OSHA requirements. The top of the staircase shall attach to the front head of the tank to allow easy tank-top filling. Stairs and handrail shall be fabricated from carbon steel, and the stair treads and platform shall be constructed of slip-resistant grating.

J. All exterior steel surfaces, including the interior of the containment dike, shall be grit blasted at the factory to SSPC-SP7 and coated with epoxy, polyurethane, or enamel white finish.

K. The tank and dike shall be provided with separate lifting lugs so that the tank and dike may be lifted separately.

L. Level/leak detection systems:

1. Each tank shall be supplied with a side-mounted level/leak detection system designed to monitor the tank contents level and the interstitial tank space for leakage of product from the primary tank.

2. High level alarms shall be set to alarm when tank levels reach 90% full.

3. Insulation in the interstitial space shall not interfere with the migration of liquid to the leak detection monitoring location.

4. Each detection system shall be provided with the following:

   a. Intrinsically safe leak detection system.

   b. Intrinsically safe level detection system.

   c. Level/leak detection system control panel housed in a NEMA 4X enclosure with side-mounting bracket and flashing light.

   d. Two dry Form "C" contacts for remote level and leak detection alarms.

M. Containment dike:

1. Containment dike shall be furnished with support dunnage to allow for visual inspection of the containment dike bottom.

2. Containment dike shall be provided with a sump and ¾" drawoff pipe to allow liquid to be pumped out of the dike.

N. Emergency vents:

1. Tank assembly shall be provided with an emergency vent protection hood designed to prevent precipitation, ice, and other debris from rendering the emergency vent ineffective. The hood shall be designed with a cross-sectional venting area of at least 160 square inches.

2. Tank shall include an emergency vent diverter designed to divert at minimum the first 9 gallons of product emitted under emergency conditions to a tank-top reservoir using a weir plate. Emissions in excess of 9 gallons shall be directed to the containment dike through a steel chute with a rectangular cross-sectional area.

O. Piping materials shall be ASTM A53, Grade B, standard schedule, carbon steel, and galvanized. Assemble threaded joints with Teflon tape and ensure all joints are tight. Piping size shall not be less than the tank connection size or the size specified by the Manufacturer.

P. Electrical requirements:

1. All electrical wiring and equipment shall be installed in accordance with NFPA 70. Enclose all electrical wiring in conduits.

2. Provide a metal-oxide varistor-type surge suppressor at each control panel.

3. All control panels shall be NEMA 4X suitable for outdoors installation and ambient temperatures ranging from -20°F to 120°F.

4. Provide circuit breakers or fuses to protect circuits per the electrical plan and specifications.

5. Control wiring shall be provided with compression-type lugs for wire terminations. Terminations made by looping wire around a terminal are not acceptable. Control wiring shall be color-coded and tagged to relate to schematic drawings. Separate all alternating current wiring from direct current wiring.

MPT-3 Specific Tank Requirements

A. Diesel tank requirements:

1. Diesel fuel tank shall consist of an above-ground horizontal cylindrical storage tank mounted on saddles within a containment dike providing secondary containment with approximately 110% of the tank's capacity.

2. Tank shall be factory tested to the requirements of UL-2085, UL listed, and labeled with the UL label "Closed Top Diked Aboveground Tank for Flammable Liquids."

3. Tank shall be furnished with a 6" emergency vent. Vent shall be designed to relieve internal pressures in excess of 0.5 psig, and shall have a minimum 235,500 cubic feet per hour rating at 2.5 psig.

4. Tank shall be furnished with 6-inch high saddle supports.

5. Diesel tank shall include a complete dispenser system with the following:

   a. Side-of-tank dispenser system with fueling stand.

   b. 18 GPM pump with meter (115V) with ¾" x 12' UL-listed fuel hose.

   c. Automatic high-flow nozzle, ¾" hose swivel, in-line fuel filter, pump mounting bracket, 2" float level gauge, 2" aluminum normal vent cap, safebreak with straightening hose, fuel nozzle breakaway, 1" suction tube, 2" schedule 40 pipe x 8', 2" vent whistle, pump stand, and "DIESEL" lettering also indicating the tank capacity in gallons.

   d. Motor control and alarm panels installed at the locations indicated on Plans.

B. Gasoline tank requirements:

1. Fuel tank shall consist of an above-ground, double-walled, and insulated horizontal cylindrical storage tank mounted on saddles within a containment dike providing secondary containment with approximately 110% of the tank's capacity.

2. Tank shall be factory tested to the requirements of UL 2085, UL-2085 listed, and labeled with the UL label "Insulated Secondary Containment Aboveground Tank for Flammable Liquids."

3. Double-walled tank requirements:

   a. Insulating material shall have a minimum R-value of 2.1m. Insulating material shall be lightweight and porous to allow for leak migration to a monitoring point. Material shall conform to the specifications of the Steel Tank Institute.

   b. The outer shell of the double wall tank shall be 12 inches in diameter larger than the inner shell. The 6-inch annular space shall be filled with lightweight insulation material.

   c. Lightweight insulating material shall not be exposed to weathering and shall be completely protected from damage between the two shells of the double-walled tank.

   d. Tank shall be furnished with minimum 3-inch high saddle supports.

4. Gasoline tank shall include a complete dispenser system with the following:

   a. Side-of-tank dispenser system with fueling stand.

b. 18 GPM pump with meter (115V) with ¾" x 12' UL-listed fuel hose.

c. Automatic gasoline nozzle, ¾" filter adapter, 1" suction tube, in-line gasoline filter, 4" vapor recovery adaptor, 4" vapor recovery cap, pump mounting bracket, 2" float level gauge, safe break with straightening hose, 4" coax fill adapter and cap with coax drop tube, 2" pressure/vac vent, alarm system with high level and pump system, pump stand, and "GASOLINE" lettering also indicating the tank capacity in gallons.

d. Motor control and alarm panels installed at the locations indicated on Plans.

C. Oil tank requirements:

1. Oil tank shall consist of an above-ground horizontal cylindrical storage tank mounted on saddles within a containment dike providing secondary containment with approximately 110% of the tank's capacity.

2. Tank shall be factory tested to the requirements of UL-142, UL listed, and labeled with the UL label "Closed Top Diked Aboveground Tank for Flammable Liquids."

3. Tank shall be furnished with a 6" emergency vent. Vent shall be designed to relieve internal pressures in excess of 0.5 psig, and shall have a minimum 235,500 cubic feet per hour rating at 2.5 psig.

4. Tank shall be furnished with 6-inch high saddle supports.

5. Accessories:

a. Oil tanks shall have 4" stenciling on each side of tank indicating the liquid contained and the tank capacity.

b. Waste oil tank shall include a 2" float level gauge, 3"x8' vent pipe, 3" vent cap, and 8" fill cap with removable strainer.

c. All other oil and fluid tanks shall include a 2" ball valve (full flow), 2"x4' vent pipes, 2" level gauge, 2" double-tapped bushing, 2" aluminum normal vent cap, 2" fill adapter and cap, and 2" vent whistle.

6. CONTRACTOR shall provide a tank heater for each oil tank:

a. Heater shall be a flange-mounted, immersion-type heater designed for the fluid type, local temperature ranges, and operating conditions for each tank.

b. Tank heaters shall be 480V, 3-Phase or as provided on the Plans. CONTRACTOR shall provide a disconnect for the tank heater on the oil/lubricant hose reel stand for each tank.

c. Heaters, controllers, and other equipment shall be UL-listed. All wiring and other electrical work must be in accordance with the National Electric Code and the electrical section of this specification.

d. Heating elements shall be enclosed within a Schedule 40 steel pipe.

e. Heating elements must be capable of being removed without draining the tank.

f. Flange mountings for the tank heater must be liquid tight and installed in accordance with tank manufacturer's recommendations.

7. CONTRACTOR shall provide an oil dispensing system per the following requirements:

a. Work includes the pump, piping, hose reels, hose reel stand, dispenser, and all related electrical work.

b. All connections and piping must be oil-tight and checked for leakage. Piping must be Schedule 40 steel or as recommended by the pump and tank manufacturers. All piping must be capable of safely handling the pump's rated pressure.

c. Pump system shall include a disconnect switch located at the hose reel stand.

d. Pump shall include 1" suction pipe extending to 2" above tank floor.

e. System operating temperature range shall be at least 32°F to 120°F.

f. Pump requirements:

i. Tank-mounted pump in heavy-duty cast iron pump housing and water-resistant pump and motor enclosure. Pump shall be self-priming and feature on-demand switching.

ii. Pump shall have built-in check valve, bypass valve, pressure relief valve, and ¾" outlet.

iii. Motor shall be UL/CSA listed with min. 115VAC or as shown in Plans. Motor shall have permanent sealed ball bearing construction and thermal overload protection.

iv. Max. outlet pressure: 450 psi

v. Max. flow rate up to 2.5 gpm.

vi. Min. 230 VAC or as shown on Plans.

g. Dispenser requirements:

i. CONTRACTOR shall provide one automatic dispenser per each tank. Dispenser shall be heavy duty, one-piece construction with battery-powered meter, trigger guard, and rigid angled nozzle.

ii. Minimum 1,500 psi maximum operating pressure.

iii. Rated for fluid viscosities up to SAE 140.

iv. Maximum flow rate up to 8 gpm.

v. Dispenser shall include a battery-powered meter with 4-digit LCD display. Meter shall handle both dispense and totalizer quantities.

vi. Meter shall be powered using AA batteries, which shall be replaceable without memory loss.

vii. Meter shall have 0.5% or less error at flow rates greater than 0.5 gpm.

h. Hose reel requirements:

i. Hose reel shall be intended for use in transferring oil and other vehicular fluids.

ii. Hose length of 75 feet and ¾" diameter.

iii. Operating temperature range between -10°F and 140°F.

iv. Bearings shall be constructed of carbon steel.

v. Hose reel shall have a maximum working pressure of at least 1,500 psi.

8. Provide a hose reel tank stand meeting the following requirements:

a. Construct one stand per tank meeting the requirements contained in the Plans and section MF – Metal Fabrication. Anchor base plates into PCC pad.

b. Mount pump control switch and heater disconnect on stand.

c. Mount oil system hose reel and dispenser on stand.

MPT-4 Measurement and Payment

A. Measurement and payment shall be per each type and size of tank furnish and installed per the Contract unit price. Price shall include the tank with containment system, all specified accessories, complete dispenser system, alarm and sensor systems, electrical/control wiring, pump stands, and all other material and labor costs required. Oil tanks shall include oil hose reel and hose reel stand.

END OF SECTION

Section MPR – Maintenance Pad Equipment Racks

MPR-1 Description

Work includes construction of heater and maintenance pad equipment racks as shown on Plans and described in this section. Work also includes furnishing and installing electrical cord reels with outlets, outlet boxes, and other equipment as specified for each rack.

MPR-2 Material

A. Electrical cord reels shall meet the following requirements:

1. Cord reels shall be spring-powered with 40-foot cables designed for outdoor industrial applications. Main spring shall be containerized.

2. Cable guide should be adjustable with an anti-cable lock-out.

3. Cord reel must be UL listed and CSA certified.

4. Reels must include a corrosion-resistant powder-polyester surface.

5. Securely attach cord reels to frames per manufacturer's instructions.

6. Cord reels shall have the following NEMA plugs:

   a. Hydraulic oil heaters: 220V with NEMA 6-20 twist-lock plugs

   b. Battery warmer: 120V with NEMA 5-20 twist-lock plugs

   c. Block heater: 120V with NEMA 5-20 twist-lock plugs

MPR-3 Heater and Equipment Racks

A. General frame construction:

1. Heater and equipment racks shall be constructed in accordance with section MF – Metal Fabrication and as shown on plans.

2. Racks shall be primed and painted safety yellow.

B. Maintenance pad equipment racks shall include the following items or as shown on Plans:

1. One 480V, 60A welder outlet.

2. Weatherproof GFCI quad box.

3. Compressed air outlet for tires at 165 psi per plans and section AS –Air Systems.

4. Compressed air outlet for tools at 100 psi per plans and section AS –Air Systems.

5. One hydraulic oil heater cord reel. (220V with NEMA 6-20 twist-lock plugs)

6. One battery warmer cord reel. (120V with NEMA 5-20 twist-lock plugs)

7. One block heater cord reel. (120V with NEMA 5-20 twist-lock plugs)

8. Pressure washer disconnect switch per electrical plans.

C. Pad-side heater racks shall include the following items securely fastened per manufacturer's instructions:

1. Two hydraulic oil heater cord reels. (220V with NEMA 6-20 plugs)

2. Two battery warmer cord reels. (120V with NEMA 5-20 plugs)

3. Two block heater cord reels. (120V with NEMA 5-20 plugs)

4. Electrical panel, transformer, and other equipment as shown in electrical plan and specifications.

MPR-4 Measurement and Payment

A. Measurement:

1. Maintenance pad equipment racks shall be measured per each rack installed, including cord reels.

2. Pad-side heater stations shall be measured per each station installed, including cord reels.

B. Payment:

1. Payment for maintenance pad equipment racks shall be made per each at the Contract unit price. Price shall include all materials, labor, cord reels, and installation costs. The price shall not include the compressed air outlet or electrical items.

2. Payment for the pad-side heater stations shall be made per each at the Contract unit price. Price shall include all materials, labor, cord reels, and installation costs. Price shall not include other electrical items installed on the rack.

END OF SECTION

Section OWS – Oil-Water Separator

OWS-1 Description

Work under this section includes furnishing a complete factory-built Oil-Water Separator ("OWS") as indicated on the project Plans. The purpose of the OWS system is to treat industrial stormwater in satisfaction of the NPDES operating permits.

Piping leading up to the OWS shall be covered under other sections of this specification.

OWS-2 General

A. The separator shall be designed for gravity separation of sand, grit, settleable solids, or semisolids and free oils (hydrocarbons and other petroleum products) from wastewater associated with railroad maintenance operations. Separator shall be installed belowground with top access at or above grade level. The source of the influent to the separator shall be gravity flow from storm water runoff, hydrocarbon spills, and/or cleaning/maintenance operations.

B. Provide OWS designed for intermittent and variable flows of water, oil, or any combination of non-emulsified oil-water mixtures in the flow ranges shown on the Plans. Operating temperatures of the influent oil shall range from 35°F to 90°F or as shown on Plans. The specific gravities of the oils and fresh water in the operating temperature range shall be as shown on the Plans or Contract Documents.

C. The free oil and grease concentration in the effluent from the OWS shall not exceed the requirements shown on the Plans and local NPDES permitting requirements.

D. OWS shall comply with the following design criteria:

1. The separator shall be listed to Underwriter's Laboratories UL-SU2215. Construction and performance of the oil/water separator must be in accordance with UL-SU2215. Provide certification documentation detailing criteria under which the system was tested. UL-SU2215 label shall be prominently displayed on manway covers.

2. Separator shall be designed in accordance with Stokes Law and the American Petroleum Institute Publication 421, "Monographs on Refinery Environmental Control - Management of Water Discharges; Design and Operation of Oil/Water Separators." The total effective surface area of the parallel flat/corrugated plate coalescer shall be 299.55 sq. ft. The total effective surface area of the polypropylene impingement coalesce shall be 31,490.13 sq. ft. Calculations, signed and stamped by a Registered Professional Engineer shall be submitted to document specified effluent quality based on complete removal of the specified oil globule. A separator with lower effective surface areas is not permissible.

3. Separator capacities, dimensions, construction, and thickness shall be in strict accordance with Underwriters Laboratories, Subject UL-58 Standard for Safety, Steel

Underground Tanks for Flammable and Combustible Liquids, September 30, 1997, Double-Walled construction with 360 degree Steel Secondary Containment. The inner steel tank shall be completely contained within the outer steel tank, enclosing 100% of the tank volume. The tank must have a double steel shell with a space between the layers. The space between the inner and outer steel walls shall be monitored with an approved electronic leak detection device through a pipe that extends vertically to the top of the tank from a small sump at the bottom. Tank construction using thin walled primary tank with external fiberglass jacket shall not be permissible.

4. Separator Corrosion Control System shall be in strict accordance with Underwriters Laboratories Inc. Subject UL-1746 Standard for External Corrosion Protection Systems for Steel Underground Storage Tanks and HighGuard® External Corrosion Protection Specifications.

5. Oil/water separator shall comply with National Fire Protection Association NFPA 30 Flammable and Combustible Liquids Code, 2003 Edition.

6. Separator vessel volume shall allow for a hydraulic retention time of ten (10) minutes to ensure laminar flow conditions which result in hydraulic uniformity and high effluent quality. Volume reduction will adversely affect separator performance by increasing horizontal velocity and turbulence, therefore a separator of smaller volume is not permissible.

7. Separator shall be the standard patented product of a steel tank manufacturer regularly engaged in the production of such equipment. Manufacturer shall have at least 15 years experience in manufacturing similar units for identical applications. No subcontracting of tank fabrication shall be permitted.

8. Separator shall be fabricated, inspected, and tested for leakage before shipment from the factory by manufacturer as a completely assembled vessel ready for installation.

9. Separator shall be cylindrical, horizontal, atmospheric-type steel vessel intended for the separation and storage of flammable and combustible liquids. The separator shall have the structural strength to withstand static and dynamic hydraulic loading while empty and during operating conditions. The Oil/Water Separator's dimensions and thickness shall be in strict compliance with Roark's Formulas for Stress and Strain as presented in UL 58, September 30, 1997. Calculations, signed and stamped by a Registered Professional Engineer shall be submitted to document structural strength under specified overbearing or external pressure. A separator with a reduced shell thickness is not permissible.

10. Separator shall have an oil storage capacity equal to about 43% of the total vessel volume and an emergency oil spill capacity equal to 80% of the total vessel volume.

11. To prevent extensive shutdown and maintenance, the separator design must allow solids to fall unhindered by turbulence, and oil droplets to rise without risk of reemulsifying due to collisions with interfering solids. The use of plastic perforated

tubes, spherical balls, or irregular shaped media will increase the facility's maintenance costs and shall not be permitted.

12. Separator shall consist of inlet and outlet connections, integral sand interceptor compartment, non-clogging flow distributor and energy dissipater device, stationary under flow baffle, presettling chamber for solids, sludge baffle, oil coalescing chamber with removable parallel flat/corrugated plate coalescer, with removable plates, and sectionalized removable polypropylene impingement coalescers to optimize separation of free oil from water, effluent downcomer positioned to prevent discharge of free oil that has been separated from the water, access ways for coalescers and each chamber, fittings for vent, oil pump-out, sampling, gauging, leak detection, and lifting lugs.

E. Submittals:

1. Prior to fabrication, CONTRACTOR shall submit six copies of submittal data to the ENGINEER for review and approval.

2. Submittal shall include shop drawings support data as follows:

   a. Catalog cut sheets reflecting characteristics for major equipment items, materials, major dimensions, hydraulic, and effluent quality analyses.

   b. Shop drawings providing layout of mechanical equipment and anchor bolt locations for OWS. Pipe penetrations and access clearances shall be clearly dimensioned. Shop drawings shall include electrical circuit diagrams.

   c. Effluent quality calculations signed and stamped by a Professional Engineer registered in the appropriate state.

   d. Operations and maintenance manuals for OWS shall include:

      i. Operation shall be in accordance with written instructions provided by the OWS manufacturer. Comprehensive instructions supplied at time of shipment shall enable personnel to properly operate and maintain all equipment supplied. Content and instructions shall assume operating personnel are familiar with oil and water separation but lack experience on exact equipment supplied.

      ii. Documentation shall be specific to the separator supplied and collated in functional sections. Each section shall combine to form a complete system manual covering all aspects of equipment supplied by the OWS manufacturer. Support data for any equipment supplied by others, even if mounted or included in overall system design, shall be provided by those supplying the equipment.

iii. Functional descriptions of each major component complete with operating instructions. Calibration and adjustment of equipment for initial start or as required for routine maintenance.

iv. Support data for commercially available components not produced by the manufacturer, but supplied in accordance with the specifications, shall be supported by literature from the prime manufacturer and incorporated as appendices.

v. Electrical schematic diagram of circuits shall be in accordance with NFPA 79. Schematics shall illustrate, to the extent of authorized repair, control and alarm system circuits including interconnections. Wire numbers and legend symbols shall be shown. Schematic diagrams for individual components, not normally repairable by the operator, need not be included. Details for such parts shall not be substituted for an overall system schematic. Partial schematics, block diagrams, and simplified schematics shall not be provided in lieu of an overall system diagram.

vi. Operation and maintenance instructions that rely on vendor cut-sheets and literature that include general configurations, or require operating personnel to selectively read portions of the manual shall not be acceptable. Operation and maintenance instructions must be specific to equipment supplied in accordance with these specifications.

F. Warranty:

1. The manufacturer shall warrant its products to be free from defects in material and workmanship for a period of one year from start-up or 18 months from shipment, whichever occurs first. The warranty shall be limited to repair or replacement of the defective part(s).

2. Manufacturer shall provide a 10-year minimum warranty for corrosion and structural defects.

OWS-3 Material

A. The Oil-Water Separator shall include the following:

1. OWS shall be prefabricated double-walled, gravity displacement underground separator having the size, capacity, and other characteristics shown on the project Plans.

2. OWS shall be furnished with coalescers and other equipment as specified on the Plans.

3. OWS shall be a pre-packaged, pre-engineered unit ready to install.

4. Internal flanged influent nozzle connection of 12" diameter or as shown on the Plans. Nozzle at the inlet end to be located at the furthest diagonal direction from the effluent discharge opening.

5. Integral sand interceptor compartment of the size and dimensions shown on the Plans. Compartment shall include one 24-inch diameter manhole that shall be UL-approved with extension, cover, gasket, and bolts. A heavy-duty bulkhead shall retain sand, grit, settleable solids, or semi-solids and prevent them from entering the separation chamber. Bulkhead shall have transfer pipe.

6. The velocity head diffusion baffle at the inlet shall:

    a. Reduce horizontal flow velocity and turbulence.

    b. Distribute flows equally over the OWS cross-sectional area.

    c. Direct flow in a serpentine path in order to enhance hydraulic characteristics and fully-utilize all separator volume.

    d. Completely isolate all inlet turbulence from the separation chamber.

7. Sediment chamber to disperse flow and collect oily solids and sediments.

8. Sludge baffle to retain settleable solids and sediment, and prevent them from entering the separation chamber.

9. An Oil/Water Separation chamber containing a removable inclined parallel flat/corrugated plate coalescer. The coalescer shall have individual removable plates, sloped inwards towards the sediment chamber. Each coalescing plate shall be flat on top and corrugated on the bottom. The flat top plate shall resist clogging and clotting with solids. The corrugations of each of the plate bottoms shall be shaped and positioned to enhance collisions between the rising oil droplets and coalesce between them. In addition, the coalescer shall:

    a. Affect separation of oil and solids from all strata of the wastewater stream. Shorten the vertical distance that an oil globule or solid particle has to rise or sink, respectively, for effective removal. The minimum plate gap to be ¾-inch.

    b. Enhance coalescence and agglomeration by causing the smaller globules and particles (those possessing smaller rising/settling rates) to coalesce and collect on the plates thereby forming larger globules and particles that separate rapidly in water.

    c. Direct the flow paths of the separated oil to the surface of the separator and separated solids to the bottom of the separator.

    d. Allow solids to fall unhindered by turbulence, and oil droplets to rise without risk of re-emulsifying due to collisions with interfering solids.

10. The Oil/Water Separation Chamber shall also contain a sectionalized removable polypropylene impingement coalescer designed to intercept oil globules of less than 20 microns in diameter. Heavy, one-piece impingement coalescers are not permissible.

11. An internal effluent downcomer at the outlet end of the separator, to allow for discharge from the bottom of the separation chamber only.

12. A flanged effluent connection of 12" diameter or as shown on Plans.

13. Fittings for vent, interface/level sensor, leak detection, waste oil pump-out, sampling, and gauge.

14. One 24" diameter manhole and one 48" x 78" coalescer access hatch, UL approved, complete with extension, cover, gasket, and bolts. One manway shall be placed between the inlet and the parallel flat/corrugated plate coalescer to facilitate access into sediment chamber for solids removal. One manway shall be placed between the parallel flat/corrugated plate coalescer and outlet to facilitate access into the oil water separation chamber for oil removal.

15. Lifting lugs at balancing points for handling and installation.

16. Identification plates: Plates to be affixed in prominent location and be durable and legible throughout equipment life.

17. Corrosion Protection System consisting of:

    a. Isolation Spool Pieces.

    b. Dielectric Isolation Gaskets and Bushings.

    c. External surfaces commercial grit blast, coated 75 mils DFT Self-Reinforcing Polyurethane.

    d. 10-year Warranty.

18. Internal surfaces commercial grit blast and coated with 10 mils DFT heavy duty polyurethane

B. Other materials:

1. Separator shall be supplied with an audible and visual alarm system that indicates high oil level and an audible and visual leak detection alarm system that indicates hydrocarbon and/or water in the interstice. A silence control shall be provided for the audible alarms. Level sensor(s) to be intrinsically safe. Level sensor floats to be made of stainless steel. The control panel shall contain both level sensor and leak detection control. The control panel shall be NEMA 4. Power to the control panel is to be 115 volt, single phase.

2. Separator shall be supplied with anchoring system per the project Plans and OWS manufacturer's recommendations.

OWS-4 Execution

A. Contractor shall off-load equipment at installation site using equipment of sufficient size and design to prevent injury or damage. Separator manufacturer shall provide written instruction for proper handling. Immediately after off-loading, CONTRACTOR shall inspect complete OWS and appurtenances for shipping damage or missing parts. Any damage or discrepancy shall be noted in written claim with shipper prior to accepting delivery. Validate all OWS serial numbers and parts lists with shipping documentation. Notify the manufacturer's representative of any unacceptable conditions noted with shipper.

B. Excavation & Bedding

1. The bottom of the excavation shall be covered with a minimum of 12 inches (305mm) of bedding, suitably graded and leveled. Bedding and backfill material surrounding the tank, to a width and depth of 12 inches (305 mm) all around the tank, shall be clean material.

2. Where anchoring by means of a concrete pad, the tank shall not be placed directly on the pad. Bedding material at least 6 inches (152.4 mm) deep must be spread evenly over the dimensions of the pad to separate the tank from the pad.

3. Unless otherwise noted on plans, bedding and backfill material shall consist of homogenous pea gravel, crushed stone, clean sand or natural earthen materials. Crushed stone, clean sand and natural earthen materials shall be capable of passing 100% through a 1/2 inch (13 mm) sieve and no more than 12% by dry weight through a #200 sieve (0.0029 inch (0.0754 mm)). Pea gravel shall be no larger than 3/4-inch (19 mm). The materials shall be free of all foreign materials; such as but not limited to, bricks, metals, concrete and plastics. The backfill material may be from the tank site if it meets the description, or it may be delivered to the site from another source. Sand or natural earthen materials used as backfill shall be placed into the excavation in 12-18 inch (305-458 mm) vertical lifts, compacted after each lift, at least 60% up the vertical height of the tank. If earthen material from the site, or other earthen material, is to be used as bedding or backfill material, a minimum of four 1 cubic-foot samples shall be taken from different locations which are representative of the backfill material and the site. Samples shall be sieved to determine if the material compiles with this specification.

C. Air Testing at Job Site

1. The temporary plugs and thread protectors installed by the manufacturer shall be removed. Apply compatible, non-hardening pipe sealant to internal bushing threads. Permanent metal plugs shall be installed at all unused openings.

2. Plugs used to temporarily seal the tank for the aboveground air test, but later removed for pipe installation, shall not be over-tightened. Do not cross thread or damage the threads when replacing plugs or installing required tank piping.

3. Test pressure shall be maintained at, but not exceed, 5 psig (34.5 kPa) while a soap solution is applied to the area of pipe connections and welds. Gauge pressure shall be maintained for test duration of a minimum of 5 minutes.

4. Dual wall tanks will require different air pressure testing procedures. Do not connect a high pressure air line directly to the interstitial monitoring port A factory applied vacuum within the Interstitial space can be used in lieu of, or In addition to, the air test procedure. Consult tank fabricator for air test recommendations. Do not apply a vacuum to the primary tank or a single wall tank. PEI/RP100-2000 also provides guidelines. Take necessary safety precautions during air tests. Do not leave tanks unattended while under pressure. Avoid standing at the head of the tank, especially while applying air pressure. Use an air-pressure relief valve.

D. Tank Inspection

1. Before placing the tank in the excavation, all dirt clods and similar foreign matter shall be cleaned from the surface of the tank.

2. Visually inspect the tank for damage. Pay particular attention to areas where cladding has been gouged or abraded. Mark all areas, which appear damaged for repair. Any section of the cladding, which has been damaged beyond the surface of the cladding, shall either be repaired or spark tested. Spark testing shall be done with a holiday detector set at a minimum 10,000 volts.

3. Coat all holidays, damaged cladding, and/or exposed steel surfaces using touch-up kit furnished by tank supplier. Follow manufacturer's instructions for mixing and application of resin. All holidays shall be re-tested at 10,000 volts.

E. Tank Handling

1. Equipment to lift the tank shall be of adequate size to lift and lower the tank without dragging or dropping to prevent damage to the tank or the coating.

2. Tank shall be carefully lifted and lowered by the use of cables or chains of adequate length attached to the lifting lugs provided. A spreader bar should be used where necessary. Under no circumstances shall chains or wire rope slings be used around the tank shell.

F. Anchoring

1. High water tables or partially flooded excavation sites exert significant buoyant forces on tanks. The weight of the tank, backfill and the pavement shall be neglected in buoyancy calculations. Additional buoyant restraint when required, shall be obtained by using properly designed hold-down straps in conjunction with concrete

hold-down pads or deadman anchors. The use of steel cable or round bar as hold-down straps is prohibited.

2. If a metallic hold-down strap is used, a pad of inert insulating di-electric material must be used to insulate the hold-down strap from the tank. The separating pad shall be wider than the hold-down straps, which will prevent direct contact between the straps and the tank shell. This pad is not required if the hold-down strap is fabricated from non-conductive material.

3. Ballasting the tank may be necessary. When water is used as the ballast material, it shall only be potable water and shall not remain in the tank longer than 60 days. During construction, adequately vent all tank spaces. If product is used as ballast, proper precautions must be taken to prevent fires, spills, leaks, and other associated accidents. Monitor product level frequently to ensure there has been no unaccounted loss of product.

OWS-5 Measurement and Payment

A. OWS shall be measured and paid on a per-each basis for each complete unit as described in this section and the project Plans.

1. Payment for the OWS shall include all costs for a complete and fully-functional system. This includes but is not limited to excavation, subgrade preparation, OWS, motor operated valves, piping, pipe connections, anchoring, vents, leak detection systems, testing, mechanical connections, flame arrestors, monitoring equipment, and electrical connections.

2. Influent and effluent piping to the OWS shall be installed and paid separately under sections DR – Drainage and SS – Sanitary Sewer.

END OF SECTION

Division IX: Traffic Control

Section LP – Traffic Loops

Section PM – Pavement Markings

Section RTS – Remote Tire Spikes

Section SG – Signs

Section LP – Traffic Loops

LP-1 Description

Work shall consist of furnishing and installing a traffic loop detector in new or existing pavement. Installation includes lead-in cables installed in conduit, sealant, and testing.

LP-2 Material

A. All traffic loops shall be minimum 14-guage AWG with XLPE insulation conforming to IMSA 51-5.

B. Preformed loop ties for installation in new concrete shall be vinyl.

C. Joint sealant shall meet and/or exceed ASTM D 5893-96 "Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements," Type NS (Non-Sag).

D. Backer rod shall be closed-cell, expanded polyethylene foam rod.

LP-3 Installation

A. General requirements:

1. "Equipment provider" includes AGS technology provider, tire spike supplier, gate arm supplier, traffic signal controller supplier, traffic detector manufacturer, or the supplier of any equipment using the individual traffic loop.

2. Confirm loop locations, inductance requirements, and other requirements with equipment provider and ENGINEER prior to installation.

3. Feeder line shall be installed in a ¾" conduit. Twist feeder wires a minimum 6 twists per foot between the loop and the equipment pedestal.

4. Paint a 2" yellow "+" mark at the center of each traffic loop.

5. CONTRACTOR shall avoid splicing cables where possible. Any splices that are installed must be encapsulated with sealant to ensure a water-tight splice.

B. Installation in asphalt and existing pavement:

1. Set saw cut to a depth that ensures a minimum of 1" from the top of the wire to the pavement surface. The saw cut width should be at least ¼" wide and wide enough to allow for wire installation without damaging the wire insulation.

2. Mark loop layout on pavement prior to saw cutting. Remove sharp corners by making corner cuts such that the maximum wire angle is 45°. Blow out slots clear of moisture and debris.

3. Use a wood stick or roller to carefully insert the wire into the loop slots. Do not use sharp objects or damage the wire insulation. Wire must be placed at the bottom of the saw cut to ensure a 1" minimum cover.

4. Wrap at least three turns in each traffic loop, unless otherwise directed by the ENGINEER, project Plans, or equipment provider. Each turn shall be formed of one continuous wire. Turns shall not be separate loops.

5. Install backer rod to firmly hold loops in place with 1" minimum cover and apply sealant. Do not apply sealant when air temperature is below 35°F or during precipitation. Ensure that the slot is completely filled and no voids remain. Remove excess sealant from road and protect sealant from traffic during curing.

C. Preformed loop detectors in new PCC pavement:

1. Afix preformed conduit to PCC rebar or reinforcements per manufacturer's requirements.

2. Preformed loops shall include at least three turns in each traffic loop, unless otherwise directed by the ENGINEER, project Plans, or equipment provider. Each turn shall be formed of one continuous wire. Turns shall not be separate loops.

3. Maintain at least 1" clearance between traffic loop wires, rebar, and pavement surface.

4. Install traffic loop and concrete pavement so as to avoid damage to the traffic loops.

LP-4 Testing

A. The CONTRACTOR is responsible for testing each traffic loop detector for leakage resistance, and inductance. CONTRACTOR shall measure inductance before application of sealant and again after work has been completed.

B. CONTRACTOR shall present all testing results for ENGINEER's approval. CONTRACTOR shall also provide testing results to the equipment suppliers.

C. CONTRACTOR is responsible for repairing or replacing any defective traffic loop.

D. Leakage resistance shall be greater than 10 megohms when tested at 375 V (DC) minimum or as required by the equipment manufacturer.

E. Series resistance shall not exceed 2.6 ohms per 1,000 feet or as required by the equipment manufacturer.

F. Inductance shall be between 50 – 700 microhenries.

LP-5 Measurement and Payment

A. Traffic loops shall be measured and paid per each loop installed. Payment shall include marking, saw cutting, coordination, materials, labor, sealant, and testing. No separate payment shall be made for replacing defective loops.

END OF SECTION

Section PM – Pavement Markings

PM-1 Description

The Work shall consist of the furnishing of materials and the application of pavement markings in accordance with these Specifications and the plans, or as directed by the ENGINEER. It shall include, but is not limited to, solid lines, skip lines, directional arrows, numerals, etc.

PM-2 Material

A. Acrylic paint shall meet the requirements of AASHTO M-248-91 Type 1 ready-mixed white and yellow traffic paints. Paint shall be lead free and low VOC.

B. Glass beads shall meet AASHTO M 247, Type 1, without flotation properties, but coated for moisture resistance, and shall be kept dry during storage and prior to use. Glass beads shall be applied to markings as indicated on the plans.

C. Long-life thermoplastic pavement markings shall meet the requirements of AASHTO M 249-11. Unless otherwise noted on plans, thermoplastic pavement markings shall be used for stop bars, lettering, arrows, and other markings subject to repeated traffic.

D. Paint color shall be yellow unless otherwise designated on the plans.

PM-3 Layout and Premarking

A. The CONTRACTOR shall layout the location of all lines, letters and other symbols to assure their proper placement as shown on the plans. The layout and premarking lines shall be approved by the ENGINEER before marking operations are started.

B. Premarking shall be located from survey data or reference points and offset so as to parallel the theoretical edge of the marking lines.

C. Pavement marking lines shall be straight or smoothly curved and true to the alignment.

D. All letters, numerals and symbols shall conform to the Federal Highway Administration "Standard Alphabet for Highway Signs" and the "Manual for Uniform Traffic Control Devices," unless otherwise shown on the Plans.

E. All lines shall be 4 inches wide, unless otherwise shown on the plans or directed by the ENGINEER.

F. Skip lines shall be applied in an 8 foot cycle consisting of a 3 foot painted segment and a 5 foot gap between painted segments, unless otherwise shown on the plans or directed by the ENGINEER.

PM-4 Application of Pavement Markings

A. Pavement markings shall be applied when:

1. ENGINEER has approved the pavement.

2. ENGINEER has approved the layout and premarking lines.

3. Pavement surface is dry and clean of all dust, dirt, grease, oil, or other foreign matter. Portland cement concrete surface shall be clean of membrane curing material.

4. Pavement surface and air temperature are above 40°F.

5. Wind conditions are such that the glass bead application shall not be impaired or dust shall not settle on the pavement during application.

B. Application of standard pavement marking paint:

1. Paint shall be thoroughly mixed at all times during application. No thinning of the paint is allowed.

2. Application shall be by pressure sprayer except for areas or markings that are not adaptable to machine marking.

3. The minimum application rate shall be 15 mils Wet Film Thickness (approximately 88 sq. ft./gallon) or as recommended by the manufacturer.

4. If specified on the plans, glass beads shall be applied at a rate of 6 pounds per gallon of paint to the wet paint so that beads are embedded and retained in the paint and uniformly cover the paint surface. Glass beads must be uniformly applied to the marking and not hand-thrown.

5. Templates shall be used for the application of arrows, letters, numerals and other symbols.

C. Application of long-life thermoplastic pavement markings:

1. Preformed thermoplastic markings shall be melted using flame from a propane-type torch according to manufacturer's recommendations in order to bond the markings permanently in position.

2. Extruded thermoplastic must be heated uniformly and applied at a temperature between 400°F - 425°F. Surface temperature must be a minimum of 50°F. Thermoplastic traffic markings must be extruded to a minimum thickness of 90 mils.

3. If specified on the plans, glass beads shall be applied at a rate of 10 pounds per 100 square feet of markings. Glass beads must be uniformly applied to the marking and not hand-thrown.

4. Templates shall be used for the application of arrows, letters, numerals and other symbols. Dimensions of letters, numerals, symbols, etc. shall be as shown on the plans.

D. Pavement marking shall be completed during daylight hours, except by permission of the ENGINEER.

E. All surfaces must be thoroughly dry prior to application, and work must take place during anticipated dry weather conditions.

F. The CONTRACTOR shall protect freshly painted areas by the use of traffic cones, warning devices, flags, or flagmen.

G. Pavement markings damaged by traffic or pavement marked by traffic crossing wet paint shall be corrected by the CONTRACTOR at no cost to the COMPANY.

PM-5 Pavement Marking Removal

A. This work includes the removal of all types of pavement markings as shown on the project plans or directed by ENGINEER.

B. Pavement lines and symbols shall be removed by high pressure water blasting, sand blasting, high temperature burning with excess oxygen, or other methods approved by the ENGINEER.

C. Pavement marking removal methods shall not scar, discolor, or otherwise damage the structure or texture of the pavement. The pavement surface shall be left in a condition that will not mislead or misdirect traffic flows.

D. Existing markings shall be removed an additional 1 inch beyond each side of pavement markings being removed.

E. The CONTRACTOR must provide any temporary traffic control necessary to keep existing traffic flows or facility operations active during work. Traffic control and phasing plans must be approved by the ENGINEER.

F. Pavement markings shall be removed so that the pavement surface is in proper condition for adequate bonding of new pavement markings. The pavement surface must be properly cleaned following marking removal as work progresses. Blown air used to clean pavement markings must be directed away from personnel, parked vehicles, and other equipment.

PM-6 Measurement and Payment

A. Measurement

1. Solid lines shall be measured along the centerline of each line by the number of linear feet of solid lines placed.

2. Multiple solid lines shall be measured along the centerline of lines by the number of linear feet of multiple solid lines placed.

3. Skip lines shall be measured along the centerline of each skip line by the total linear feet of run placed (not total skip line length).

4. Letters, numerals or other symbols shall be measured by the number of each type and size of letters, numerals or other symbols placed or as stipulated on the Schedule of Prices.

5. Pavement stripe removal shall be measured along the centerline of the actual lines removed. Removal measurements shall not include spaces between skip stripes.

6. Removal of letters, numerals, or other symbols shall be measured by the number of each type and size of symbols removed or as stipulated on the Schedule of Prices.

B. Payment

1. Payment for solid lines will be made at Contract unit price per linear foot, which shall include all necessary materials, labor, and equipment.

2. Payment for multiple solid lines will be made at Contract unit price per linear foot, which shall include all necessary materials, labor, and equipment.

3. Payment for skip lines will be made at the Contract unit price per linear foot of painted line, which shall include all necessary materials, labor, and equipment.

4. Payment for letters, numerals and other symbols will be made at the Contract unit bid price per each type and size of letters, numerals and other symbols placed or as stipulated on the Schedule of Prices, which price shall include all necessary materials, labor and equipment.

5. Payment for pavement stripe removal shall be made at the Contract unit price per linear foot of painted line, which shall include all necessary materials, labor, and equipment.

6. Payment for pavement symbol removal shall be made at the Contract unit price per quantity stipulated on the Schedule of Prices, which shall include all necessary materials, labor, and equipment.

7. No separate payment will be made for layout or traffic control.

END OF SECTION

Section RTS – Remote Tire Spikes

RTS-1 Description

The CONTRACTOR shall furnish and install a complete remote tire spike system for installation at the locations indicated on the project plans. This work shall include all tasks related to installation of the remote tire spike system, except for specific tasks that are included as separate bid items within the project's bid sheet.

RTS-2 Operational Requirements

A. General:

1. The normal position of the remote tire spike blades shall be in the down position. Gate arm shall be raised when tire spike blades are in the down position. Traffic signal shall indicate green or proceed as shown on Plans.

2. Tire spike system shall be capable of detecting vehicles currently crossing over the tire spikes, and preventing activation while the area is occupied.

3. Tire spike systems shall include a separate push-button control to activate all facility tire spikes under emergency shutdown conditions.

B. The tire spike system shall adhere to the following procedure when activated:

1. Traffic signal shall indicate yellow while gate arm is lowered (2.5 second cycle).

2. Traffic signal shall indicate red once gate arm is fully lowered.

3. Tire spikes blades shall rise only once signal is red and gate arm is fully lowered.

C. The tire spike system shall adhere to the following procedure when de-activated:

1. Tire spike blades shall fully lower.

2. Traffic signal shall indicate yellow while gate arm is raised (2.5 second cycle).

3. Traffic signal shall indicate green or proceed once gate arm is fully raised.

D. Outbound installations:

1. Outbound remote tire spikes shall receive signals to activate or deactivate from the central Automatic Gate System server.

2. Return-to-yard indicator signals, if included in Plans, shall signal trucks to proceed to the return-to-yard lane if the tire spike traffic signal is red or yellow.

E. Inbound installations:

1. Inbound tire spikes shall automatically detect for vehicles exiting the facility in the unauthorized direction of travel and activate when detection occurs without receiving a signal from the central Automatic Gate System server.

2. Inbound tire spikes shall be capable of detecting trucks approaching from the authorized direction of travel, and preventing tire spike activation under an authorized truck.

3. Traffic detector loops shall be installed in the locations shown on the Plans.

RTS-3 Material

A. Remote tire spike system components:

1. General:

a. Remote tire spike system shall be motor-driven and capable of bi-directional traffic.

b. Tire spike system shall be provided by a manufacturer with a design intended for heavy truck traffic operations. Prior to ordering material, manufacturer must provide documentation of successful installations in at least five other locations with similar traffic loadings in the past three years.

c. Tire spike assembly shall consist of retractable blades mounted on individual modules. Several modules and a motor box assembly shall be mounted on pre-cast trench segments and connected to each other. Trench modules in turn shall be embedded in a reinforced cast-in-place foundation and connected with drains.

d. Entire tire spike assembly shall be mounted flush with the pavement to provide a smooth driving surface for trucks traveling over the tire spikes.

e. Entire tire spike system and components shall be powered using 110V power unless otherwise directed on Plans.

f. Tire spike system manufacturer shall supply the following as an integrated system:

i. Tire spike modules with blades and control rod. CONTRACTOR shall procure the equivalent of 8 – 20" modules for lane widths of 12 feet or less. For lane widths greater than 12 feet, CONTRACTOR shall procure sufficient modules to provide a width at least 1 foot greater than the lane width. Tire spike module lengths do not include motor box units.

ii. Prefabricated trench segments to accommodate tire spike modules and motor unit.

iii. Tire spike motor unit.

iv. Heating elements and related equipment.

v. All control and electrical wiring between the control box and the tire spikes, gate arm, and traffic signal(s).

vi. Prefabricated loops and loop detectors.

vii. Gate arm barrier system with padded gate arm.

viii. Spare tire spike blades (5).

2. Tire spike blades:

   a. Tire spike blades shall be individually mounted on each module and shall retract perpendicular to the direction of travel (retract in-line with tire spikes).

   b. When retracted, blades shall sit flush with the module in order to allow trucks to pass.

   c. Blades shall be field serviceable and replaceable.

   d. Blades shall be mounted to modules using two mounting plates per blade, with at least two mounting screws per plate.

   e. Blades shall be at least 3-7/8" wide and exactly 2-3/4" high. Blades shall be shaped with four separate angles for insertion into vehicle tires. The two outside angles shall be 77° from horizontal, and the inside angles shall be 48.5° from normal.

   f. Blades shall be constructed of 17-4PH stainless steel, CB7 Cul., ASTM A747. Blades shall be solution annealed and aged (H925 condition) to a minimum hardness of RC38. Finish of blades shall be 125 RMS, and blades shall be powder coated to resist corrosion.

3. Tire spike modules:

   a. Tire spike modules shall be at least 6.6250" wide and between 18"-24" long, and contain five individual retractable blades 4" on center.

   b. Modules shall be constructed and designed to mount flush with pavement surface.

   c. Modules shall be field serviceable and replaceable. Tire spike system shall be designed to remove individual modules.

   d. Modules shall be mounted to prefabricated trench units using between 4-8 hex bolts.

e. Modules shall include ball connections to adjacent modules or the motor box, and shall include individual control rod segments to transfer force between the motor unit, adjacent modules, and individual blades. Control rod must provide full retraction or activation of every blade on the tire spike system.

f. Each module shall be designed to handle at least 50 tons of force.

g. Modules shall be constructed of 356 T51 aluminum. Each individual module shall not weigh more than 25 pounds fully assembled.

h. Modules shall include removable protective rubber covers to prevent debris build up on both inbound and outbound units

4. Tire spike motor unit:

a. Electric motor shall have at least 250 pounds of torque, and be capable of raising or lowering all tire spike blades in 1 second or less.

b. Electric motor shall be installed in a watertight box mounted on a precast trench segment adjacent to the tire spike modules.

c. All electrical components shall be UL listed, and all electrical work shall be in accordance with the electrical specifications.

d. Motor shall be capable of handling tire spike systems up to 20 feet in length.

5. Prefabricated trench segments:

a. Manufacturer shall supply prefabricated trench segments to mount individual tire spike modules and the motor unit. Prefabricated trench segments shall be cast into a reinforced concrete foundation as shown on the Plans.

b. Trench segments shall be the same width as the tire spike modules, and shall accommodate one or two full tire spike modules per trench segment.

c. Trench segments shall include pre-formed holes for mounting tire spike modules and the motor unit.

d. Each trench segment shall include a 3” diameter drainage knock-out. Knockouts shall be no more than 40” on center in final installation.

e. Trench segments shall be designed with interlocking male and female ends to provide a firm connection until the concrete foundation has set.

6. Pole-mount box and control equipment:

a. Tire spike control equipment shall be mounted in a NEMA 4 box mounted in the location shown on the Plans, or no more than 7 feet from the tire spikes.

b. Pole-mount box shall be at least 30”x 24”x10” and be mounted for easy access.

c. Pole-mount box shall include the following equipment:

i. Pre-wired breaker box with at least four breakers. Breakers shall include one 20-amp breaker for the tire spike system and battery backup, one 20-amp breaker for heating elements, one 20-amp breaker for the gate arm, and one outlet breaker.

ii. 12V DC backup power source providing at least 8 hours of operation.

iii. Electronics to operate the tire spike system.

iv. A two-button (raise/lower) pendant for activation of the system during maintenance and testing.

v. Heating element equipment.

vi. GFCI outlet (120V)

vii. Two-position switch to bypass tire spike activation and AGS signals

7. Heating elements:

a. Tire spike installations shall include heating elements to prevent ice build-up in the tire spike trench and motor unit.

b. Tire spike system shall include at least two heating elements to heat the tire spike modules and a third self-regulating element to heat the trench segments and drains.

c. Heating elements shall extend the full length of the tire spike trench, including the full length of all modules and the motor box.

B. Gate arm:

1. Gate arm shall have a 2.5 second cycle.

2. Gate arm shall be the same length as the lane width. Gate arm shall be OSHA yellow and padded.

C. Traffic signal:

1. Tire spike signal shall be a standard 120V LED red-amber (yellow)-green traffic signal.

2. Signal shall be mounted on a pole adjacent to or above the pole-mount control box.

3. Signal shall be powered and controlled by the tire spike control box.

4. Signal shall be mountable on a square steel post as shown on the Plans, and shall include all mounting hardware to affix signal to square post.

D. Traffic loops:

1. All traffic loops shall be prefabricated and cast into concrete pavement.

2. Insulated lead-in cables shall be installed inside ¾" conduit to the gate arm pedestal.

3. Contractor shall not install any underground conduit within 4 feet of any proposed loop.

4. Traffic loops shall conform to the tire spike manufacturer's requirements.

E. Tire spike drain:

1. CONTRACTOR shall 3"-diameter tire spike drains every 40 inches to properly drain the tire spike trench.

2. Drain pipes shall connect to a 6" outlet pipe as shown on plans. CONTRACTOR shall install a cleanout on the upstream end of the tire spike.

3. Tire spike drain system shall be composed of schedule 80 PVC unless otherwise noted on Plans.

F. Tire spike foundation concrete shall conform to section SC – Structural Concrete. Concrete shall be at least 3,000 psi.

RTS-4 Installation

A. Trench preparation:

1. CONTRACTOR shall saw cut existing pavement prior to pavement removal.

2. Trench shall be excavated and base shall be compacted to 95% standard Proctor.

3. CONTRACTOR shall install PVC drain system and conduit in accordance with Plans and tire spike manufacturer requirements. Install drains in accordance with section DR – Drainage.

4. CONTRACTOR shall place at least 12" dense graded aggregate base for foundation. Base shall be compacted to 95% of AASHTO T-99.

5. Trench shall be constructed with a 2% cross-slope to provide proper drainage.

B. Concrete foundation:

1. CONTRACTOR shall complete tire spike foundation prior to installing adjacent PCC pavement.

2. CONTRACTOR shall install prefabricated trench segments with tire spike modules in place to prevent warping during concrete pours.

3. Concrete shall be 3,500 psi or greater, and shall be constructed in accordance with section SC – Structural Concrete. All rebar shall be grade 60. Dowels shall be cast into the concrete, and shall be at least 1.5”-diameter or as shown in plans.

4. Per manufacturer’s instructions, prefabricated trench segments may rest on concrete blocks to provide proper installation height for the trenches.

5. Apply sealant per tire spike manufacturer’s instructions to connect prefabricated trench segments.

6. Final trench shall be constructed with a 2% cross-slope to provide proper drainage.

7. Prior to final pouring, secure trench segments by pouring small sections of dry-mix concrete around each segment joint.

8. Seal all end caps and trench/module edges with duct tape prior to pouring.

9. Secure all trench segments from uplift during the final pour.

10. After pouring, thoroughly vibrate concrete to eliminate air pockets and smooth concrete surface surrounding the trenches. Allow concrete to achieve expected strength.

11. Clean all debris from trench after concrete foundation has set.

C. Other:

1. Install heating elements, motor unit, pole mount box, gate arm, and other equipment per manufacturer’s instructions after completing tire spike foundation.

2. CONTRACTOR shall pour adjacent PCC pads no fewer than 7 days after pouring tire spike foundation.

RTS-5 Testing and Warranty

A. CONTRACTOR shall test the tire spike system to the satisfaction of the ENGINEER. Initial testing shall include repetitive actuation of the tire spike system, heating elements, and other equipment.

B. CONTRACTOR is responsible for replacing damaged or defective equipment and making necessary repairs.

C. CONTRACTOR shall provide a one-year warranty for all items installed under this proposal, including that the systems operate as specified. Under this warranty, the

CONTRACTOR will pay for any additional labor or parts to correct any defects or make necessary modifications to the system.

RTS-5 Measurement and Payment

A. Payment for the proposed remote tire spikes shall be paid per each tire spike set installed, unless otherwise specified on the project bid sheet. This unit includes excavation and furnishing and installing bedding, foundation, tire spike modules, heater, prefabricated trench, and activator box.

B. Payment for the proposed gate arm shall be paid per each gate arm and pedestal installed, unless otherwise specified on the project bid sheet. This unit includes excavation and furnishing and installing bedding, concrete pedestal, conduit inside of the foundation, gate arm, and all work inside the gate arm enclosure.

C. Payment for the proposed traffic signal pole shall be paid per each signal pole installed, unless otherwise specified on the project bid sheet. This unit includes excavation and furnishing and installing bedding, concrete foundation, conduit inside of the foundation, pole mount box, steel pole, highway signs on pole as shown on plans, and red-yellow-green traffic signal.

END OF SECTION

Section SG – Signs

SG-1 General

Work shall include furnishing and installing reflective highway signs. This specification does not apply to special-designed signs or decorative entrance signs.

SG-2 Material

A. Signs

1. Sign layouts shall conform to the "Manual of Uniform Traffic Control Devices" and the "Standard Highway Signs and Markings" published by the Federal Highway Administration.

2. Signs shall be constructed of aluminum sheeting.

3. Signs shall be painted and reflectorized according to local DOT standards. Sign markings must be clear cut and free of waviness, unevenness, furry edges, cracking, blistering, or other defects when installed.

B. Posts

1. Posts shall consist of "U"-channel galvanized steel conforming to ASTM 499, Grade 60.

2. Posts should include 3/8"-diameter bolt holes spaced 1 inch on center. Holes must be drilled.

3. Posts shall be coated according to ASTM A 123 after the holes have been drilled.

SG-3 Installation

A. Drive-type posts may be driven in place only in areas with firm and stable soil.

B. In areas of sandy or unstable soil, posts must be installed in a prepared dry hole at least 6 inches in diameter. Prepared holes must be backfilled with Portland cement and tamped thoroughly.

C. Posts must be vertical and in the orientations shown on the Plans.

D. Signs must be securely fastened to posts with two or more fasteners.

SG-4 Measurement and Payment

A. Signs shall be measured and paid per each size of sign. Payment shall include posts.

END OF SECTION

Division X: Security Systems

Section FOC – Fiber Optic Cable Infrastructure

Section VSS – Video Security System General Requirements

Section FOC – Fiber Optic Cable Infrastructure

FOC-1 Description

Work shall include furnishing, installing, terminating, and testing the fiber optic cable infrastructure as shown on the project Plans. Work includes all connectors, patch panels, patch cables, and other apparatus required for completion of the infrastructure.

FOC-2 Fiber Optic Cable Requirements

A. General Requirements:

1. All personnel shall handle fiber strands with attention to personal safety. Workers shall not look at fiber strands until they have personally confirmed that the strand is disconnected.

2. The cable shall meet all requirements stated in this specification. The cable shall be a listed product of the United States Department of Agriculture Rural Utilities Services (RUS) 7 CFR1755.900 and the ANSI/ICEA Standard for Fiber Optic Outside Plant Communications Cable, ANSI/ICEA S-87-640-1992.

3. The cable shall be new, unused, and of current design and manufacture.

4. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding. The fiber shall be matched clad design.

5. Optical fibers shall be placed inside a loose buffer tube. The fibers shall not adhere to the inside of the buffer tube.

6. The maximum pulling tension shall be 2700 N (608 lbf) during installation (short term) and 890 N (200 lbf) long term installed.

7. Optical fibers:

   a. All fibers in the cable must be usable fibers and meet required specifications.

   b. Maximum individual fiber attenuation for single-mode fibers shall be 0.40dB/km @ 1310nm, 0.30dB/km @ 1550.

   c. The maximum dispersion shall be <3.2 ps/(nm_km) from 1285 nm through 1330 nm and shall be <18 ps/(nm_km) at 1550 nm.

   d. Each fiber shall be distinguishable from others by means of color coding in accordance with EIA/TIA-598-A, "Optical Fiber Cable Color Coding." The ink for coloring fibers shall be UV cured, no thermal inks shall be used in the coloring process.

8. Buffer tubes:

    a. Each buffer tube shall contain up to 12 fibers.

    b. The nominal outer diameter of the buffer tube shall be 3.0 mm.

    c. Buffer tubes containing fibers shall also be color coded with distinct and recognizable colors in accordance with EIA/TIA- 598, "Optical Fiber Cable Color Coding."

        i. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1 mm.

        ii. For dual layer buffer tube construction cables, standard colors are used for tubes 1 through 12 and stripes are used to denote tubes 13 through 24. The color sequence applies to tubes containing fibers only, and shall begin with the first tube. If fillers are required, they shall be placed in the inner layer of the cable. The tube color sequence shall start from the inside layer and progress outward.

    d. In buffer tubes containing multiple fibers, the colors shall be stable during temperature cycling and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

    e. The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrink back requirements of 7 CFR 1755.900.

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

    g. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "SZ", stranding process. Water blocking yarn(s) shall be applied longitudinally along the central member during stranding.

9. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.

10. The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

11. For single layer cables, a water blocking tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The tape shall be held in place by a single polyester binder yarn. The water blocking tape shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter. Dual layer cables shall be water blocked in a similar fashion.

12. Two polyester yarn binders shall be applied contra helically with sufficient tension to secure the buffer tube layer to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.

13. The cable shall contain at least one ripcord under the sheath for easy sheath removal.

14. Tensile strength shall be provided by high tensile strength aramid yarns and/or fiberglass yarns. Aramid yarns and/or fiberglass yarns shall be helically stranded evenly around the cable core.

15. Sheath:

    a. The cable shall be sheathed with medium density polyethylene. The minimum nominal strength members and water blocking tape. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

    b. The jacket or sheath shall be free of holes, splits, and blisters.

    c. The cable jacket or sheath shall contain no metal elements and shall be of a consistent thickness.

    d. The cable jacket or sheath shall be marked with "'Manufacturer' Optical Cable," sequential foot markings, year of manufacture, fiber count and fiber types, EX (72f, 36 sum, and 36 mm 62.5/125). The actual length of the cable shall be within -0+1% of the length markings.

    e. The marking shall be in contrasting color to the color of the cable jacket or sheath. The height of the marking shall be approximately 2.5 mm.

B. Single-Mode Fiber Requirements:

1. Typical Core Diameter: 9 µm.

2. Cladding Diameter: 125.0 ± 1.0 µm.

3. Core-to-Cladding Offset: <0.8 µm.

4. Cladding Non-Circularity: < 1.0%.

    a. Defined as: [1-(min. cladding dia. max. cladding dia.)] X 100

5. Coating Diameter: 245 ± 10 µm.

6. Colored Fiber Diameter: nominal 250 µm.

7. Attenuation Uniformity:

    a. No point discontinuity greater than 0.10 dB at either 1310 nm or 1550 nm.

8. Attenuation at the Water Peak:

    a. The attenuation at 1383 ± 3 nm shall not exceed 2.1 dB/km.

9. Cutoff Wavelength:

    a. The cabled fiber cutoff wavelength (ccf) shall be < 1250 nm.

10. Mode-Field Diameter:

    a. 9.30 ± 0.50 μm at 1310 nm

    b. 10.50 ± 1.00 μm at 1550 nm

11. Zero Dispersion Wavelength: 1301.5 nm <o <1321.5 nm.

12. Zero Dispersion Slope (So): <0.092 ps/(nm²km).

13. Polarization Mode Dispersion: <0.5 ps/sq.rt. km

14. The coating shall be a dual layered, UV cured acrylate applied by the fiber manufacturer.

15. The coating shall be mechanically strippable without damaging the fiber.

C. Hybrid Fiber Optic Cable:

1. Cable shall be gel-free, single jacket, single armor hybrid fiber optic cable.

2. 12 MMFO (62.5 microns core/125 microns cladding) / 12 SMFO (8.3 microns core/125 microns cladding).

3. 6 MMFO (62.5 microns core/125 microns cladding) / 6 SMFO (8.3 microns core/125 microns cladding)

4. Single-mode fiber shall

FOC-3 Enclosures

A. Splice case must handle up to **four** cables and be intended for buried applications. A butt adapter, if applicable could be used to increase capacity to eight cables.

B. Splice case shall be non-filled (no encapsulate), will prevent water intrusion and shall allow re-entry without any special tools. The closure shall be capable of preventing a 3 meter (10 foot) water head from intruding into the splice compartment for a period of 7 days.

C. The enclosure shall be capable of accommodating splice organizers which accept mechanical, single fiber fusion, or multi fiber splices. The enclosure shall have provisions

for storing fiber splices and unspliced fiber/buffer tubes. The enclosure shall hold a minimum of 2 splice trays to a maximum of 15 splice trays with each tray housing up to 24 splices. The closure shall be UL rated.

D. Enclosures shall include, but not be limited to, three (minimum) entry ports that can be sealable with conduit / innerduct fittings to prevent passage of gas, dust, and water from the exposed environment into the enclosure, space to organize and coil cable fiber buffer tubes, and splice tray capacities (can be multiple trays) to accommodate a minimum of 24 splices or connector terminations (as required). Splice enclosures shall satisfy Bellcore GR-771-CORE, (Hermetically Sealed Closures) requirements ASA minimum.

E. The splice enclosure shall provide space, allowing entry of fiber optic cable without exceeding the minimum bend radius of the cable.

F. The enclosure shall have provisions for cable and pigtail strain-relief, and shall be equipped with strain-relief hardware.

G. The splice enclosure shall be designed to permit selective fiber splicing (looping a backbone cable in and out while only cutting into the desired fibers).

H. The size of the enclosure shall allow all the fibers of the largest optical fiber trunk cable to be spliced to a second cable of the same size, plus additional pigtails.

I. The splice enclosure shall allow splicing of all fibers up to the maximum number specified on the Plans.

J. Closure re-entry and subsequent reassembly shall not require specialized tools or equipment.

K. Use fiber optic splice closures that are impact-and corrosion resistant and waterproof when immersed in 10 feet of water.

L. Fiber optic splice enclosures shall be fully compatible with all components of the fiber optic infrastructure as specified, including but not limited to fiber optic trunk cable, fiber optic drop cable, and fiber optic fusion splices.

M. Enclosure shall be a cylindrical dome-type splice with cable entry at one end only and a sealed single-molded piece dome body of high density polyethylene or equivalent non-metallic material.

    1. The cable entry end shall be manufactured of a similar material as the dome body and shall seal the closure with flexible thermoplastic rubber or polymer gasket

    2. The cable entry end shall include cable entrance ports that shall seal the cable and port opening with flexible thermoplastic rubber or polymer gasket seals with mechanical compression.

3. Closures shall be re-enterable and re-sealed without the need for specialized tools or equipment, or the use of any additional parts.

4. Do not use any heat shrink or caulk/encapsulate materials for sealing the assembled closure or terminated cables.

N. Provide splice closures with maximum outer dimensions of 8.0 inches diameter and 21 inches length:

1. Splice closures shall provide cable entrance ports for at least four fiber optic cables.

2. At least two cable entrance ports shall accommodate cables of at least 0.60 inches outer diameter.

3. The closure shall allow for the storage and express of at least 6 unopened buffer tubes.

O. Provide a splice closure with a cable entry end with pre-template cable ports and a split-plate design permitting installation of the closure in mid-span cable segments.

P. The splice closure size identified specifies the minimum number of fusion splices to be accommodated by the closure. With the splice closure, provide all materials to accommodate the number of splices specified by the closure size, including splice tray, storage, and organizing materials.

FOC-4 Ancillary Material

A. Pre-terminated fiber optic cable assembly:

1. These assemblies shall be employed when connecting a camera, or other device to the main cable when mid-span access techniques are used.

2. Assemblies shall be factory assembled & terminated on one end with ceramic ferrule, LC compatible, heat cured epoxy connectors with an operational temperature of -40C to +70C. Each connector shall have a minimum of a 1-inchstrain relief boot.

3. Insertion loss for each connector shall not exceed .30dB for both single mode assemblies. Return loss for single mode connectors shall be >-45dB. Each assembly is to be fully tested and those test results placed on a test tag for each assembly. Each assembly is to be individually packaged within a box or reel, with the submitted manufacturer's part number marked on the outside of the package.

4. Individual 250 um coated fibers shall be up-jacketed to 3.0mm using fan-out tubing. This tubing shall contain a 900um Teflon inner tube, aramid yarn strength members, and an outer jacket. The fan-out tubing shall be secured to the cable in an hard epoxy plug transition. Length of the individual legs shall be a minimum of 36 inches with the length difference between the shortest and longest legs of the assembly being no more than 2 inches.

B. Connectors:

1. Provide fiber optic connectors compliant with this specification or all fiber optic infrastructure including but not limited to fiber optic termination cabinets, fiber optic drop panels, and fiber optic patch cords.

2. Provide only factory-installed keyed LC compatible connectors for all fiber optic infrastructure. Provide only factory-installed connectors of a type other than LC when required by the Project requirements. Do not use field-installed connectors. Do not use adapter couplers to change connector types.

3. Use ceramic ferule connectors factory-installed with a thermal-set heat-cured epoxy and machine polished mating face. Install connectors as per manufacturer application and recommendations, including proper termination to the outer-tubing (900 micron tubing, 3 mm fan out tubing, etc.) required for the application.

4. Use connectors rated for an operating temperature of -40°C to +75°C.

5. Provide connectors that have an installed insertion loss of less than 0.50 dB, a typical loss of 0.20 dB, and a optical return loss of greater than 45 dB.

6. Use simplex connectors for all male LC connectors. Provide latching cover for two male connectors being used in a duplex configuration. Female couplers may be duplex but must allow simplex mating connectors.

7. Label each fiber position on panels and termination cabinets containing duplex couplers with the port/position ID as shown in the Plans.

8. Provide dust caps for all exposed male connectors and female couplers at all times until permanent connector installation.

C. Fiber optic patch cables:

1. It is not permissible to use fiber/copper media converters when using fiber optic cables to interconnect LAN switches and/or routers. Only internal fiber optic transceivers should be used for this purpose.

2. Fiber patch cables must be approved by the COMPANY's Manager of IT Network Projects.

3. Fiber patch cables must meet the following requirements:

   a. Provide fiber optic patch cords consisting of a length of fiber optic cable terminated on both ends.

   b. All patch cords shall be factory preconnectorized assemblies adhering to all applicable cable and fiber specifications stated in these Specifications.

c. Provide patch cords of the appropriate length for the necessary connections, maintaining minimum bend radius, and with no residual strain at the connector or anywhere on the patch cord itself beyond self-support. Patch cords shall not have excess length beyond what is necessary for equipment connection and routing.

d. All patch cords shall be duplex zip-cord fiber cable with simplex LC connectors, except as otherwise allowed in these specifications.

i. The two connectors of each end of the patch cord shall be differentiated by different colors.

ii. Provide sufficient flexibility at each end to disconnect one connector without disturbing the other, or to allow swapping of the two connectors within the same duplex coupler without disturbing the remainder of the patch cord.

iii. Provide strain relief and reinforcement at the point where the duplex cable separates for the individual simplex connectors.

e. Use yellow outer jackets for single mode fiber.

f. No splices of any type are allowed within a patch cord assembly.

g. Fully test each patch cord assembly at the source of manufacture and place those test results on a test tag for each mated pair of connectors. Attach the associated tag to one end of each fiber within the duplex assembly

4. Any patch cords used for system configuration shall be compatible with fiber types and connectors specified herein. Single-mode patch cords shall be yellow in color and each jacketing material shall conform to the appropriate NEC requirement for the environment in which installed.

D. Flexible fabric innerduct:

1. This item is intended for installation of one or more fabric innerducts in an installed conduit as specified on the Plans.

2. This work shall consist of furnishing, installing a flexible fabric innerduct system. It includes all materials associated with the installation and termination of the flexible fabric innerduct innerduct system.

3. Flexible fabric innerduct shall meet the following requirements:

a. Min. tensile strength: 2,500 lbs.

b. Min. melting point: 400°F

c. Accomodates cable sizes up to 1.375” O.D.

d. Resistant to spiraling when installed with a swivel.

e. Each innerduct cell shall include an individual pull cord.

4. CONTRACTOR shall include one separate pull wire separate from the innerduct in each conduit for future use.

5. CONTRACTOR shall terminate and splice fabric innerducts in accordance with manufacturer requirements.

FOC-5 Installation

A. Cable installation:

1. Do not exceed maximum pulling tension.

2. Maintain manufacutrer's minimum bend radius.

3. Avoid sharp bends and corners.

4. Do not deform the cable jacket.

B. Fiber optic cable connections:

1. Each cable shall be individually attached to the respective termination panel by mechanical means. The cables strength member(s) shall be securely attached the cable strain relief bracket in the panel.

2. Each fiber cable shall be stripped upon entering the termination panel and the individual fibers routed in the termination panel.

3. Each fiber bundle shall be stripped upon entering the splice tray and the individual fibers routed in the splice tray.

4. A maximum of 24 strands of fiber shall be spliced in each tray

5. Each cable shall be appropriately labeled at each termination point or splice location per this specification.

6. Dust caps shall be installed on the connectors and couplings at all times unless physically connected.

C. CONTRACTOR shall include the appropriate amount of slack or storage at the following locations. Slack shall be neatly coiled within panels or pull boxes:

1. Fiber optic cable: 50 feet inside pull box and at all other splice locations

2. FOC drop cables: 50 feet at splice location

3. Patch jumper FOC: 3 feet in cabinet

4. Exterior ethernet cable: 50 feet at pull box, 3 feet fully inside buildings or cabinets

5. Patch/Jumper F.O. Cables- 3 feet in the cabinet

D. Backbone cables shall be installed separately from horizontal distribution cables or as shown on the plans.

E. Where cables are housed in conduits, the backbone and horizontal cables shall be installed in separate conduits or in separate innerducts ‘within conduits.

F. The shipping, storage, and operating temperature range of the cable shall be -40degreeC to +70degree C. The installation temperature range of the cable shall be -30degreeC to +70degree C.

G. Cable configurations required for this project are displayed in the plans.

FOC-6 Labeling

A. CONTRACTOR shall provide fiber optic cable labels meeting the following requirements:

1. Polyetheylene or equivalent material with UV and fungus inhibitors.

2. Base materials and graphics/printing inks/materials designed for underground outside plant use including solvent resistance, abrasion resistance and water absorption.

3. Orange label body with pre-printed text in bold black block-style font with minimum text height of 0.375”.

4. Minimum size: 3.875” W x 1.75” H

5. Minimum thickness: 0.010”

6. Slots (6): 0.255” X .12”

B. At minimum, pre-print the following (at minimum) text legibly on labels used for all fiber optic trunk cables (FO Cable):

1. “CAUTION / FIBER OPTIC CABLE” warning text.

2. Fiber count and type (MM/SM).

3. Cable from and to locations.

C. CONTRACTOR shall submit final labeling scheme and materials to the ENGINEER for approval prior to starting work.

FOC-7 Testing and Repairs

A. The CONTRACTOR shall be responsible for all testing, and shall submit the testing results to the ENGINEER for approval. The CONTRACTOR shall be responsible for repairing or replacing all fiber optic cable, connectors, and other equipment in order to meet the testing requirements.

B. Fiber optic cable testing:

1. All fiber must be terminated and tested (OTDR and Power Loss). The installer shall provide printed record of the fiber optic test. No spliced or broken fibers will be accepted. A calculated fiber loss budget will be in keeping with the characteristics of the fiber with allowances for splices and terminations. This allowance will be within the EIA/TIA defined guidelines for fiber optic cable testing. The actual fiber losses for a given link will compare favorable (less than) to the calculated loss budget.

2. Field testers for multimode optical fiber shall meet the requirements as specified in International Standard ISO/IEC11801 latest edition, One Jumper Reference; single mode shall meet the requirements as specified in International Standard ISO/IEC11801 latest edition, method A.1, One Jumper Reference.

3. The insertion loss for each mated fiber-optic connector pair shall be ≤ 0.75 dB. Reflectance for single-mode single fiber UPC cable assemblies shall be ≤ -55 dB. Mated connector pair loss testing shall be based on one unidirectional OTDR inspection.

4. In addition to connector insertion loss for each mated pair, the CONTRACTOR shall perform end-to-end insertion loss testing for each multimode fiber at 850 nm and 1300 nm from one direction, and for each terminated fiber span in accordance with EIA/TIA-526-14A (OFSTP 14) and single-mode fibers at 1310 nm and 1550 nm from one direction for each terminated fiber span in accordance with TIA/EIA-526-7 (OFSTP 7). For spans greater than 90 meters, each tested span must test to a value less than or equal to the value determined by calculating a link loss budget. For horizontal spans less than or equal to 90 meters, each tested span must be < 2.0 dB.

5. Inspect each terminated multimode fiber span for continuity and anomalies with an OTDR at 1300 nm from one direction in accordance with the OTDR operating manual for systems greater than 100 meters. Inspect each terminated single-mode fiber span for continuity and anomalies with an OTDR at 1550 nm from one direction in accordance with OTDR operating manual for systems greater than 100 meters.

C. Enclosure Testing:

1. Testing of the closure is to be accomplished by the placing of the closure into a pressure vessel and filling the vessel with tap water to cover the closure. Apply continuous pressure to the vessel to maintain a hydrostatic head equivalent to 3 meters on the closure and cable. This process shall be continued for 7 days. Remove

the closure, open to check for the presence of water. Any intrusion of water in the compartment containing the splices constitutes a failure. It is the responsibility of the Contractor to insure that the water immersion test has been performed by the manufacturer or an independent testing laboratory, and the appropriate documentation has been submitted to the COMPANY.

2. For compression testing, the closure shall not deform more than 10% in its largest cross-sectional dimension when subjected to a uniformly distributed load of 1760 Newtons at -18degreeC and +38degreeC. The test shall be performed after stabilizing at the required temperature for a minimum of two hours. It shall consist of placing an assembled closure between two flat parallel surfaces, with the longest, closure dimension parallel to the surfaces. The weight shall be placed on the upper surface for minimum of 15 minutes. The measurement shall then be taken with the weight in place. It is the responsibility of the Contractor to insure that the compression test has been performed by the manufacturer or an independent testing laboratory, and the appropriate documentation has been submitted to the city.

FOC-8 Payment and Measurement

A. Payment and measurement for fiber optic cable installation shall be per each linear foot installed by type of cable. Payment shall include all material, labor, termination, splices, splice enclosures, and testing. No separate payment shall be made for repairs made prior to system acceptance.

B. Payment and measurement for pre-terminated drop cables and associated splices shall be paid per section VSS – Video Security System as part of camera installations.

END OF SECTION

Section VSS – Video Security System General Requirements

VSS-1 Description

A. Description of Work:

Norfolk Southern seeks to implement a video Security system at their Intermodal Yard. The system is based on a single mode fiber backbone with wireless access at designated camera locations. The purpose of the security system is to provide Norfolk southern with the capability to detect, deter, analyze and record activity in and around their facility. The system as proposed should be easily maintainable and provide for remote viewing, as well as the reporting of activity and alarms. All components installed as part of the video system should be SNMP capable to allow for query of device status and operation. All components should be accessible from a unified control screen using a single user interface. The system should utilize an architecture that is easily integrated to other yards that may have similar video security systems.

B. Physical Environment:

A Norfolk Southern Intermodal yards consist of railroad tracks running the entire length of the yard and parking spaces for containers. Maintenance, administration, repair and refueling buildings are also present. Intermodal yards are typically in excess of 2 miles long and as such the system has been designed to provide a single mode fiber based video and a wireless system that is capable of providing perimeter security over an extended range. Within the yard there is a requirement to monitor the activity of vehicles parked and moving. In addition, activity of personnel within the yard is also to be monitored.

C. General System Requirements:

Norfolk Southern will be implementing Video Analytics on their video system. Video analytics will at a minimum consist of Motion Detection, Image classification, trip wire, directional movement detection, speed detection, loitering, unauthorized article left behind or taken, varying parameters by zone and direction of view, day/night parameter changes, alarming and reporting. These functions will be programmable by camera, location, time of day and field of view. Norfolk Southern will not accept a change in installed hardware as a requirement to use Video Analytics. The system proposed must be upgradable via software download remotely. All camera and sensor hardware installed must be capable of running Video Analytics (VA). If the proposed system needs additional software to make the device VA capable, indicate what is required, how it is deployed and include the cost in your proposal. If there is additional hardware required to run VA please include in your proposal. The wireless system should be upgradable to provide additional bandwidth for growth. This upgrade capability should be via software key and be field upgradable.

The cameras must provide tri-streaming. Each camera must generate two independent MPEG-4 streams and a JPEG with a MJPEG stream or multiple H.264 streams simultaneously. This feature will allow Norfolk Southern to stream high-quality images for live viewing while recording at a reduced frame rate, and at the same time, stream JPEG

images to a remote PDA device.

All cameras and sensors must be able to track objects as they pass through the field of view. This tracking capability within the camera should additionally be capable of supporting scripts or nested scripts to allow Norfolk Southern to customize the alarm and motion detection. The sensors will be used to secure the perimeter. The sensors should have the capability to track an object or objects using one or more PTZ cameras together or independently located within the yard.

Cameras and Sensors are located on 40', and 70' light poles. When the camera is mounted on the light ring the physical interface to the light ring will be a 1.5" male connector. This connector will be the only installation point for the Camera and supporting electronics. The Video System installed on this light ring may not exceed 20 lbs. Additionally electronics required to support the camera will be housed in a NEMA cabinet mounted on the concrete foundation of the light pole. Cameras and Sensors may also be installed on traditional wooden poles. Each device within the camera system located in the yard should be able to be power cycled individually, remotely. Surge protection should be provided for all cabling, coax, power, data and Ethernet entering and leaving the camera enclosure. Equipment cabinets mounted at the base of the light poles will be rated NEMA 4. The equipment cabinet will house a UPS that will power the equipment housed within the cabinet and the attached Video components for 6 hours. A managed Ethernet switch, 120VAC surge protector, Ethernet surge protector (if applicable), coax surge protector, 12/24VAC surge protector, Ethernet accessible 8-port power reset switch, will all be housed within the Equipment Cabinet located at the base of the pole.

Norfolk Southern estimates that the storage media where all video images will be recorded, should be at a minimum 5 terabytes. This will allow the flexibility to record multiple video streams from each camera. The cameras and sensors will "write" directly to the ISCSI drive, thus eliminating additional equipment, complexity and additional points of failure. A RAID type drive is required to allow Norfolk Southern to design the storage with redundancy.

Network management of the system and the operator interface will be from multiple networked locations and support multiple levels of passwords for access into the system.

VSS-2 General Requirements:

A. The video security system includes the following components and subsystems:

1. Thermal video detection and surveillance systems.

2. Target tracking system.

3. Closed-circuit television cameras (CCTVs).

4. iSCSI Disk Array.

5. Wireless radio.

6. Ethernet switch.
7. Surge suppressors (specific for security system).
8. Network management software.
9. Video surveillance monitoring and suppository.
10. IP video encoder.
11. IP-based power reset.
12. Equipment cabinets
13. SNMP managed ups.
14. Fiber optic cable infrastructure per Section FOC – Fiber Optic Cable.

B. All submittals shall be approved by the ENGINEER and the COMPANY's designated IT Managers ("COMPANY I.T. Managers"). The COMPANY IT Managers shall include one representative from the COMPANY's Department of Information Technology and one representative from the COMPANY's Intermodal Department.

C. Contractor requirements and submittals:

1. The CONTRACTOR shall be familiar and competent with the installation, service, and maintenance of all video security system components. The CONTRACTOR and all personnel must be properly trained to perform all tasks in accordance with manufacturer requirements, these specifications, the project plans, and applicable government requirements.
2. As part of the bid submittals, the CONTRACTOR shall submit documentation of at least three similar video security system installations within the past three years.

D. Product submittals:

1. CONTRACTOR shall submit cut sheets, specifications, manufacturer information, installation methods, parts, connectors, and other relevant information for all video security system components to the ENGINEER and COMPANY IT Managers for approval prior to ordering material.

E. Execution:

1. The CONTRACTOR shall store, transport, and handle all materials and equipment with care and in accordance with manufacturer's instructions. The CONTRACTOR shall protect all devices or equipment from damage.

2. The CONTRACTOR is responsible for repairing or replacing all failed equipment or cables caused by improper handling, faulty equipment, or damage caused by the CONTRACTOR.

3. The CONTRACTOR shall coordinate with the COMPANY's IT Managers throughout the entire implementation process.

4. The CONTRACTOR is responsible for ensuring that the Video Security System is fully functional and compatible with the COMPANY's existing information technology systems.

5. The CONTRACTOR is to coordinate with the COMPANY for the installation of any cameras on proposed microwave towers or other structures.

F. Warranty:

A. The CONTRACTOR shall provide a 12-month warranty for the video security system. The warranty will start upon final system acceptance.

B. The system shall be continuously monitored by the CONTRACTOR via Norfolk Southern provided DSL circuit for 24 hours per day during the warranty period.

C. A single spare of each type of equipment used in the Video System will be inventoried at the Intermodal yard.

D. There will be a 2-hour response time required to acknowledge a problem and issue a problem resolution ticket to Norfolk Southern.

E. If there is a hardware failure that requires a technician onsite, the time to site will be no longer than 8-hours. The technician will replace the defective device from the spares inventory. The defective unit will be repaired or replace and returned to the inventory pool at the CONTRACTOR's expense. A Corrective Action Report (CAR) must be recorded on all equipment that has been replaced or repaired. This report must include at minimum the following: Date (failure of equipment), Model #, Serial #, Technician Name, Identified problem, Corrective Action Taken, Date (equipment put back into service or inventory).

F. Preventive maintenance will be performed once a quarter. It will consist of but not limited to cleaning of the Camera and sensor lens, checking connectors, cabling for wear and updating applicable software or firmware. All preventive maintenance that may require any outage or disruption of Intermodal workflow will require approval from Norfolk Southern prior to commencing work.

G. During the first 6 months after system acceptance. The CONTRACTOR will provide technical personnel to modify or change, system or functional parameters or configuration to devices or components in the Video system. These personnel if required will be onsite.

H. Training:

1. Norfolk Southern Intermodal yards operate 24 hours a day. As such, training for the Norfolk Southern personnel responsible for using the Video system will be scheduled to take place during their normal shift work hours. This will require three training classes per day. It is also required that the training be scheduled over a week to cover personnel that may only work on specific days.

2. All training material will be included in the training course. This material will include all operational manuals for equipment installed documentation that represents the as built Video system. All applicable IP addresses, default passwords and CONTRACTOR point of contacts for questions up to 30 days after the training course. Each student will be given a bound copy of the training course material. The CONTRACTOR will provide a sample training manual, material and procedure prior to commencing training for approval by Norfolk Southern.

3. All training shall be recorded and turned over to the COMPANY on a DVD format.

I. System acceptance:

1. CONTRACTOR must submit a system acceptance plan to the ENGINEER and COMPANY IT Managers for approval prior to testing. This plan will consist of all component testing, data throughput testing (where applicable), functional and capability testing. All camera presets, position parameters, alarming triggers, recording and viewing algorithms will be tested.

2. During the testing the ENGINEER and COMPANY IT Managers may require that parameters or configurations of a device or devices in the video system be changed or modified. These modification and/or changes will be a part of the final system testing.

3. System acceptance shall include both initial testing and a 10-day burn-in period.

4. Initial burn-in:

   a. When final system testing is completed by the CONTRACTOR and approved by the ENGINEER and COMPANY IT Managers, the video system must operate for 10 days without major error, before the ENGINEER and COMPANY IT Managers shall accept the Video system.

   b. The definition of a major error shall be defined and agreed to by the ENGINEER, COMPANY IT Managers, and the CONTRACTOR prior to the starting of the system acceptance testing.

   c. If the system does not perform satisfactorily for 10 days, the CONTRACTOR will fix the system and the components or devices that have been repaired, reprogrammed, modified or replaced will be system tested prior to commencing the subsequent 10 day burn in period.

d. The CONTRACTOR will have 30 days after initial Final System Acceptance testing to complete a satisfactory 10-day burn in. If the system has not passed the 10 day burn in, 30 days after the initial final testing, the Video system will be replaced by the CONTRACTOR with a functional system. The CONTRACTOR will submit a list of major errors that may occur during system testing to Norfolk Southern for approval, with the Final System acceptance plan.

VSS-3 Thermal Video Detection and Surveillance

A. Description

The thermal video detection system consists of intelligent surveillance cameras which receive long wavelength infrared (LWIR) radiated energy to detect objects that violate a site's alarm policies. The system provides long-range automated outdoor perimeter and buffer zone protection, operating in all weather conditions and geographical locations. The system integrates camera control, image stabilization, advanced image processing, and geo-spatial based object tracking to minimize false and nuisance alarm rates. Direct processing of video at the imager level analyzes video and provides access to the full dynamic range of the camera core, increasing the amount of image data available for processing and providing enhanced sensitivity. In its maximum range configuration, the system detects vehicle-sized objects up to 1,600 meters and humans up to 650 meters.

B. General requirements:

1. References:

a. Conformity for Europe (CE)

b. Consultative Committee for International Radio (CCIR)

c. Electronic Industry Association (EIA)

d. Federal Communications Commission (FCC)

e. Institute of Electronic and Electrical Engineers (IEEE)

f. International Electrotechnical Commission (IEC)

g. International Organization for Standardization (ISO)

h. National Television System Committee (NTSC)

i. Phase Alternation by Line (PAL)

j. Underwriters Laboratories Inc. (UL)

k. Underwriters Laboratory Canada (ULC)

l. Factory Mutual (FM)

m. National Electrical Manufacturers Association (NEMA)

2. Submittals:

   a. General: Submittals shall be made in accordance with the Norfolk Southern Conditions of Contract and Submittal Procedures.

   b. Shop Drawings and Schematics: Shall depict the Security system in final proposed "as built" configuration. The following must be provided:

      i. Connection diagrams for interfacing equipment.

      ii. List of connected equipment.

      iii. Locations for all IP addressable equipment components to be installed under this specification.

   c. Product Data: The following shall be provided:

      i. Technical data sheets.

      ii. A complete set of datasheets and manuals

   d. Quality Assurance Submittals: A final test report shall be submitted to indicate that every device was tested successfully in a system test.

3. Delivery, storage, and handling:

   a. General: Delivery, storage, and handling of thermal video detection system shall be in accordance with the manufacturer's recommendations.

   b. Ordering: The manufacturer's ordering instructions and lead-time requirements must be followed to avoid installation delays.

      i. A sunshield shall be provided for protection from the direct rays of the sun to reduce internal housing temperatures.

      ii. Where icing is to be expected, a window heater with automatic thermostat control and remote shutoff override shall be provided.

4. Project/site conditions:

   a. Temperature Requirements: Products shall operate in an environment with an ambient temperature range of -30° to +60°C (-22° to 140°F).

C. Product requirements:

1. The system shall receive infrared energy in the wavelength range of 8 – 14 micron emanating from potential objects of interest within the detection zone of the camera via an un-cooled VOx microbolometer detector.

2. The system shall provide built in electronic motion stabilization to negate the effects of wind and vibration and allow undiminished operation of the video processor.

3. The system shall electronically factor out the effects of motion in a background environment of land, sky, or water in order to allow detection of foreign objects.

4. The system shall provide discrimination of small objects in a background of scene clutter by requiring no more than sixteen (16) scene pixels for object detection.

5. Data security: The system shall be capable of providing data security through Advanced Encryption Standard (AES) encryption of video, system meta-data, and control information; authentication (basic and digest log-in); and system tamper alarms. SSL protocol shall be used for trusted external communications to other system devices.

6. GPS Registration: The system shall use a geo-registration technique to capture the GPS location of detected objects, and provide for communication of this information to other system elements providing tracking and display capability.

7. The system shall provide the following analytic capabilities:

   a. Modes: motion zone, multi-mode tripwire, directional zone violation, loitering, to and from zone

   b. Target information: height, width, speed, direction, aspect-ratio and absolute GPS position.

8. Zone configuration and requirements:

   a. The system's field of view shall be able to be divided into a collection of independent zones or regions, each with the ability to specify different alert criteria. Zones shall be capable of being designated as alarm or mask types.

   b. Each alarm type zone shall be able to be associated with a set of rules that specify more precisely the conditions under which alarms are generated. These rules must allow restricting alarms by time, by tripwire, by previous path, or by target attributes such as the target's size, speed, direction, and shape (aspect ratio). (See paragraph 2.02 G.)

9. Zone alarm triggers: The following shall be elements of zone alarm trigger criteria:

   a. Object moving within zone (default).

b. Configuration for response to analytic criteria referenced in paragraph 2.02 G.

c. Multiple per zone trigger criteria.

10. The system shall support MPEG-4 and MJPEG compression, dual streaming, up to 30 frames per second.

11. The system shall have the ability for the data to stream at a Constant Bit-rate (CBR) or Variable Bit-Rate (VBR) with independent bit-rate settings for detection and non-detection conditions.

12. The system will provide a standard 10/100 Ethernet interface and optional 802.11 a/b/g interface.

13. The system shall allow for configurable bandwidth from 64 kbps to 8 Mbps, supporting satellite, cellular, wireless, and full broadband communication

14. The system shall be housed in a NEMA 4X nitrogen-purged enclosure.

15. The system shall use a rugged, multi-contact sealed Mil-C electrical connector that supports connectivity for power and data signals in a single unit and provides the means for removal from the enclosure for maintenance and installation.

16. The system shall not require any supplemental cooling and shall be available with supplemental heating.

17. The system shall be available with multiple lens combinations.

D. System performance:

1. Detection Reliability: The system must reliably detect up to 64 human pedestrian targets in under one second, with each target occupying as few as 16 pixels, anywhere in the field of view, while simultaneously enduring a total physical imager movement of less than 100 pixels (shake from wind gusts, etc.) at a frequency of up to one hertz..

2. Object Tracking: The system shall be able to reliably track 64 objects simultaneously.

3. Field of View (FOV) and detection distance:

a. The system, when configured with appropriate lens and imager, shall detect objects directly approaching, with size as specified in this document, at the following minimum distances within the given field of view:

FOV (degrees)	Distance (meters)	Distance (feet)
50	90	300
36	120	394
20	240	787
14	340	1,115
7	650	2,132

Table 1: Thermal Detection for Approaching Objects

b. The system, when configured with appropriate lens and imager, shall detect objects moving perpendicular to the system, with size as specified in this document, at the following minimum distances within the given field of view:

FOV (degrees)	Distance (meters)	Distance (feet)
50	130	426
36	180	590
20	330	1,082
14	470	1,542
7	900	2,952

Table 2: Thermal Detection for Perpendicular Objects

4. Imager:

   a. Detector: Un-cooled VOx Microbolometer.

      i. Detector Pitch: 38 micron

      ii. Spectral Response: 8 - 14 micron

   b. Picture Elements: 320 (H) x 240 (V)

   c. Lens (fixed) views available: 7°, 14°, 20°, 36°, 50°

   d. Dynamic Range: 16 bit digital sensor interface

   e. NETD: < 85mK

   f. Focus Adjustment: Fixed focus

5. Network:

   a. Ethernet Compliance:

      i. Wired: IEEE 802.3, 802.3i, 802.3u

      ii. Wireless: IEEE 802.11 a/b/g (optional)

b. Interfaces:

i. Wired: RJ45

ii. Wireless: Integral (optional)

c. Data Rate: 64 kbps to 8 Mbps

d. Operating Mode: Full-duplex

e. Network Protocols:

i. Internet Protocol (IP), User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Dynamic Host Control Protocol (DHCP), Address Resolution Protocol (ARP), Interior Gateway Management Protocol (IGMP) 3.0, Domain Naming System (DNS), Hypertext Transfer Protocol (HTTP and HTTPS), Real-Time Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP), Network Time Protocol (NTP), Secure Shell (SSH), Secure Socket Layer/Transport Layer Security (SSL/TLS),Service Location Protocol (SLP).

6. Video Output:

a. Compression Type:

i. MPEG-4– ISO/IEC 14496-2:1999 .

ii. Simple Profile, Advanced Simple Profile.

iii. MJPEG

b. Bit Rate Profile: Constant (CBR) or variable bit rate (VBR).

c. Resolution: 320x240.

d. Frame Rates Available: 1, 2, 3, 4, 5, 6, 8, 10, 15, 20, 25, and 30 frames per second.

7. Electrical:

a. Voltage: 24 VAC/DC +/- 10%.

b. Connector (power & data): 26 pin Mil-C.

c. Power: 20 watts nominal, 60 watts w/optional heater.

8. Mechanical:

a. Weight: 15 lbs. (6.8 kg)

b.	Dimensions:	18.6” L x 6.4” W x 6.6” H
c.	Enclosure:	NEMA 4X (IP66 compliant)
d.	Nitrogen purge pressure	10 psi
e.	Mounting:	3 x ¼-20 tpi bolts
f.	Operating Temperature:	-22° to 140°F (-30° to +60°C)
g.	Storage Temperature	-22° to 158°F (-30° to +70°C)
h.	Relative Humidity:	0 to 100%
i.	Emissions:	FCC Part 15, Class A

E. Compatible system elements:

1. Tracking System: The system shall be capable of communicating with a tracking system, providing target GPS coordinates to allow PTZ camera positioning unit and continual target tracking.

   a. Communication shall be via industry standard XML over a HTTP/HTTPS interface and include real time reports of objects tracked, camera name, serial number, firmware version, GPS position, bearing, and vital operating information.

   b. Tracked object parameters must include current time, alarm state, creation time, GPS position, size, heading, speed, aspect ratio, and alarm zone.

2. Display System:

   a. Display system shall display topological position and field of view of all video detection system units, overlaid on a geo-positioned aerial image of the surveillance area. This aerial image can be in standard image formats (e.g. JPEG)

   b. Display system shall plot GPS locations of all security violations overlaid on a geo-located aerial image of the surveillance area.

VSS-4 Target Tracking System

A. Description:

The target tracking system consists of a unit which receives GPS information from intelligent detection cameras which geo-register an object that violates a site’s alarm policies. The system provides this GPS information to autonomous pan-tilt-zoom (PTZ) cameras which automatically track the object while it is within the field of view of the detection cameras. The PTZ cameras are represented as cones within a topology map that dynamically updates or is manually controlled by an operator.

B. General requirements:

1. Tracking System Requirements:

a. The system shall receive GPS coordinates in real-time from intelligent detection cameras which geo-register an object that violates a site's alarm policies.

b. The system shall process the received information at the edge of the network, without the need for a centralized server. Security policy violation alarms shall be tracked solely by using the processing resources within the tracking system processor.

c. The system shall generate real time reports of objects tracked, detection camera name, serial number, firmware version, GPS position, bearing, and vital operating information via the industry standard XML over HTTP/HTTPS interface. Tracked object parameters shall include current time, alarm state, creation time, GPS position, size, heading, speed, aspect ratio, and alarm zone.

d. The system shall be configurable for tracking priority, including first target acquired, newest target, closest target, fastest moving target, and largest target.

e. The system shall provide for dwell time adjustment, depending on target.

f. The system shall have an adjustable optical zoom setting to automatically enlarge or reduce the size of target within the field of view

g. The system shall interface with PTZ cameras using an industry standard PelcoTM D protocol via a physical EIA RS-422 interface.

h. Upon detection of an intruding object, the system shall automatically position an associated PTZ camera to zoom and track the target for up-close inspection or continuous tracking. The system shall maintain absolute position data as provided by the PTZ camera.

i. The system shall encode the video signal from PTZ camera for transport over the network to a video management system for display and archiving as required.

j. Data security: The system shall be capable of providing data security through AES 256 bit encryption. SSL protocol shall be used for trusted external communications to detection cameras and mapping software.

k. The system will provide a standard 10/100 Ethernet interface and optional 802.11 a/b/g interface.

l. The system shall be housed in a NEMA 4X enclosure.

m. The system shall use a rugged, multi-contact sealed Mil-C electrical connector that supports connectivity for power and data signals in a single unit and provides the means for removal from the enclosure for maintenance and installation.

n. The system shall not require any supplemental cooling and shall be available with supplemental heating.

2. System Performance Requirements:

a. Object Tracking: The system shall be able to reliably track 64 objects simultaneously.

b. The system shall interoperate with all Pelco™ -D compliant PTZ cameras.

c. Temperature range: The system shall operate in an environment with an ambient temperature range of -30° to +60°C (-22° to 140°F).

3. References:

a. Conformity for Europe (CE)

b. Consultative Committee for International Radio (CCIR)

c. Electronic Industry Association (EIA)

d. Federal Communications Commission (FCC)

e. Institute of Electronic and Electrical Engineers (IEEE)

f. International Electrotechnical Commission (IEC)

g. International Organization for Standardization (ISO)

h. National Television System Committee (NTSC)

i. Phase Alternation by Line (PAL)

j. Underwriters Laboratories Inc. (UL)

k. Underwriters Laboratory Canada (ULC)

l. Factory Mutual (FM)

m. National Electrical Manufacturers Association (NEMA)

4. Products:

5. Network:

a. Ethernet Compliance:

i. Wired: IEEE 802.3, 802.3i, 802.3u

ii. Wireless: IEEE 802.11 a/b/g (optional)

b. Interfaces:

i. Wired: RJ45

ii. Wireless: Integral (optional)

c. Data Rate: 64 kbps to 8 Mbps

d. Operating Mode: Full-duplex

e. Network Protocols:

i. Internet Protocol (IP), User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Dynamic Host Control Protocol (DHCP), Address Resolution Protocol (ARP), Interior Gateway Management Protocol (IGMP) 3.0, Domain Naming System (DNS), Hypertext Transfer Protocol (HTTP and HTTPS), Real-Time Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP), Network Time Protocol (NTP), Secure Shell (SSH), Secure Socket Layer/Transport Layer Security (SSL/TLS),Service Location Protocol (SLP).

6. Video Output:

a. Input: 1 volt peak-peak.

b. Output: 2 independent IP channels.

c. Compression Type:

i. MPEG-4– ISO/IEC 14496-2:1999 .

ii. Simple Profile, Advanced Simple Profile.

iii. MJPEG.

d. Bit Rate Profile: Constant (CBR) or variable bit rate (VBR).

e. Resolution: 640 x 480.

f. Frame Rates Available: 1, 2, 3, 4, 5, 6, 8, 10, 15, 20, 25, and 30 frames per second.

7. Electrical:

a. Voltage: 24 VAC/DC +/- 10%

b. Connector (power/data): 26 pin Mil-C

c. Power: 13 watts nominal

8. Mechanical:

a. Weight: 3.6 kg (8 lbs.)

b. Dimensions: 14.2" L x 6.3" W x 3.5" H

c. Enclosure: NEMA 4X (IP66 compliant)

d. Mounting: Pole or wall

e. Operating Temperature: -22° to 140°F (-30° to +60°C)

f. Storage Temperature -22° to 158°F (-30° to +70°C)

g. Relative Humidity: 0 to 100%

h. Emissions: FCC Part 15, Class A

C. Compatible System Elements

1. The video tracking system shall be capable of communicating with a video detection system, which provides target GPS coordinates to allow PTZ camera positioning unit and continual target tracking. Communication shall be via industry standard XML over HTTP/HTTPS interface and provide system characteristics including real time reports of objects tracked, camera name, serial number, firmware version, GPS position, bearing, and vital operating information.

2. Display system:

a. Display system shall display topological position and field of view of all video detection system units, overlaid on a geo-positioned aerial image of the surveillance area. This aerial image can be in standard image formats (e.g. JPEG).

b. Display system shall plot GPS locations of all security violations overlaid on a geo-located aerial image of the surveillance area with alarm condition and descriptive text indicating site, location, serial number, and timestamp.

c. PTZ cameras shall be represented as cones within a topology map that dynamically updates or is manually controlled by an operator.

d. Display system shall provide operational management and setup of all tracking system elements from one or more command points.

VSS-5 Closed-Circuit Television Cameras

A. General

1. Overview:

a. CCTV cameras shall be based on the following interchangeable modules:

i. CPU Module determines advance intelligence functions like: privacy masking, motion detection and tracking.

ii. Camera Module includes PTZ, color, Day/Night and zoom range options.

iii. Housing Module is available for indoor and outdoor applications.

iv. Communications Module determines how video and data will be communicated to the ISSCI drive, DVR or IP video system.

v. Power supply module options meet site specific installation requirements (indoor or outdoor) and protection against unexpected surges in power.

b. All modules shall allow for hotswap capability so as to change modules without having to power down the system.

c. Camera dome bubble:

i. Meets flame, crush, and impact resistant requirements able to exceed UL 746C standard for polymeric material enclosures.

ii. Is a high-resolution bubble made of acrylic

iii. Is a high-impact bubble made of at least 2.6 mm thick polycarbonate able to withstand a 100 foot-pound impact or the equivalent of a 10 lb sledgehammer dropped from a height of 10 feet.

iv. Should have a clear version.

d. Camera housing designed for outdoor pendant versions.

e. Camera dome designed with mast (pole) mount and pipe mount versions. The camera system is a Type 4X (NEMA 4X) and IP66 certified, rugged, weather-resistant package.

2. References

a. American National Standards Institute (ANSI) (www.ansi.org)

i. ANSI C63.4 Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

b. Australia and New Zealand Standards

i. AS/NZS 3548 Limits and methods of measurement of radio disturbance characteristics of information technology equipment.

c. Canadian Standards Association (CSA)

i. CAN/CSA E60950-1 Information Technology Equipment Safety.

d. European Norm

i. EN 50121-4 Railway Applications - Electromagnetic Compatibility - Part 4: Emission and Immunity of the Signaling and Telecommunications Apparatus.

ii. EN 50130-4 Alarm Systems - Electromagnetic Compatibility - Product Family Standard: Immunity Requirements For Components Of Fire, Intruder And Social Alarm Systems.

iii. EN 55022 class A (CE) – Information Technology Equipment – Radio Disturbance Characteristics – Limits and Methods of Measurement for Emission.

iv. EN 55024 Information Technology Equipment (CE) – Immunity Characteristics – Limits and Methods of Measurement.

v. EN 60950 (CE) – Information Technology Equipment - Safety.

vi. EN 61000-3-2 (CE) Electromagnetic Compatibility – Limits for Harmonic Current Emissions.

vii. EN 61000-3-3 (CE) Electromagnetic Compatibility – Limits – Limitation of Voltage Changes, Voltage Fluctuations and Limitation of Voltage.

e. Federal Communications Commission (FCC) (www.fcc.gov)

i. FCC CFR 47 part 15 class A – Telecommunications – Radio Frequency Devices – Digital Device Emission.

f. International Electrotechnical Commission (IEC)

i. IEC 60529 Degrees of protection provided by enclosures (IP Code).

ii. IEC 60950 Information Technology Equipment – Safety.

g. Institute of Electrical and Electronics Engineers, Inc. (IEEE) (www.ieee.org)

i. IEEE 802.3af Power Over Ethernet.

h. International Organization for Standardization (ISO)

i. 9001 – Quality System.

i. Underwriters Laboratories, Inc. (UL) (www.ul.com)

i. UL 50 Enclosures for Electrical Equipment.

ii. UL 2043 Fire Test for Heat and Visible Smoke Release for Discrete Products and their Accessories Installed in Air-Handling Spaces.

iii. UL 60950-1 Information Technology Equipment - Safety.

3. Definitions:

Analog Camera:

Camera with coaxial interface

IP Camera:

Conventional analog camera with an embedded encoder that directly generates IP Video stream.

Encoders and Decoders:

Devices that transmit video, audio and camera control data to IP Cameras via IP Network such as Ethernet LAN, WAN or Internet.

IP Video Management System:

Video surveillance system that enables users to view video via both a PC and analog monitors. Comprises a PC Based Host, Video Management Software, IP Cameras, IP Network switch and storage units.

iSCSI:

Refers to protocol, a standardized way to talk to IP-based storage across an IP network

B. Products:

1. System Requirements:

a. Provide a fast address method to allow the camera address number used for control to be remotely programmed from the management system.

b. Ensure that any advanced commands required to program the dome are accessed via three levels of password protection ranging from low to high.

c. Auto tracking - Provide a feature that automatically rotates, or pivots, the camera to simplify tracking of a person walking directly under the camera .

d. Provide advanced troubleshooting and diagnostics via diagnostic LEDs and on-screen diagnostic displays.

e. Possess on-screen display menus that support English, French, German, Spanish, Portuguese, Polish, Italian, Russian, Czech, and Dutch.

f. Supports an IP communication module that simultaneously streams IP video (up to 3 streams) across a local or wide area network.

g. Interface directly to a ISSCI drive for recording video data.

2. CPU Module

a. Provide fast 360º per second camera pan/tilt speeds; advanced troubleshooting and diagnostics via diagnostic LEDs and on-screen displays; and built in surge protection. The camera's 360º rotation can be divided into 16 independent sectors with 16-character titles per sector. Any or all of the 16 sectors can be blanked from the operator's view.

b. Provide 24 masks with up to 8 masks per scene that prohibit areas of the field of view from being seen even if the camera is panned, tilted, or zoomed. The masks can be shaped using three (3), four (4) or five (5) anchor points to form different shapes to best fit the area to be masked. Mask selections will be black, white or blurred.

c. Have a preset tour function. Allow the recording of two (2) separate tours of an operator's keyboard movements consisting of tilt and zoom activities, for a total combined duration time of 15 minutes. The recorded tours can be continuously played back. Preset tours should be able to be scripted and support nested scripts within the CPU module.

d. Store up to 99 preset scenes with each preset programmable for 16 character titles. Two (2) separate preset tours can be available to display consecutively the preset scenes for a programmed dwell time. Any or all of the presets can be included or excluded from the tour.

e. Provide advanced alarm handling to manage up to seven (7) alarm inputs and four (4) alarm outputs by means of a programmable "Rules" engine. Any or all of the input contacts can be programmed upon activation to automatically move the camera to any preposition location, close an output relay for a programmed period of time, transmit an alarm signal and display an alarm indication on the on-screen display of the monitor.

f. When an operator stops manual control of the camera, and a programmed period of time is allowed to expire, the camera CPU can execute one of the following programmable options: return to a stored preset number, return to the automated tour previously executed, and do nothing.

g. Provide enhanced automatic motion tracking using a dedicated digital signal processor (DSP) for smooth object tracking and the ability to follow an object continually when passing behind a privacy mask. In addition, the enhanced automatic motion detection can use Virtual Masking technology to ignore areas of extraneous background motion.

h. Provide video motion detection (VMD) that can be configured to create a region of interest within multiple preset positions where motion is to be detected. Support a total of 10 individual regions of interest (one per preset position).

i. Provide image stabilization using a dedicated digital signal processor (DSP) to minimize camera shake on both the horizontal and vertical axes while maintaining a clear image as the zoom range increases. The image stabilization algorithms should not reduce camera sensitivity.

j. Provide an AutoPivot feature to automatically rotate and flip the camera as it tilts through the vertical position to maintain the correct orientation of the image.

k. Provide an AutoScaling feature that will reduce the pan/tilt speed as the camera zooms in on an object, so that the relative speed on the screen remains constant.

3. PTV Camera Module:

a. Consist of an integrated high resolution Exview HAD CCD camera using a 1/4-inch imager and a 36x (3.4 – 122.4 mm, F1.6 to F4.5) auto-iris, auto-focus optical zoom lens with manual override. It will have a variable high speed, 360º pan/tilt drive with a top speed of 120º per second.

b. Designed to perform over a wide range of environmental and lighting conditions with a horizontal resolution of 540 TVL (NTSC/PAL) typical and sensitivity down to 0.03 lux in color mode, and 0.006 lux in night mode.

c. Switch automatically from daylight color operation to a higher sensitivity nighttime monochrome mode when light levels fall below an adjustable threshold level. Day/night operation may also be manually switched on or off from the network management system.

d. Possess a full 12X digital zoom that is functional once the maximum 36X optical zoom limit has been reached. The 12X digital zoom lens is on/off selectable from the network management system.

e. Have a Freeze Frame feature that holds a preposition shot while moving to another preposition.

f. Horizontal resolution: 540 TVL (NTSC, PAL)

g. Color mode sensitivity (30 IRE):

i. F1.6, 1/60 (1/50) shutter, max AGC

ii. SensUp Off: 0.6 lux

iii. SensUp On: 0.003 lux

h. Night mode sensitivity (30 IRE):

i. F1.6, 1/60 (1/50) shutter, max AGC

ii. SensUp Off: 0.16 lux

iii. SensUp On: 0.006 lux

i. Shutter Speed (AES): 1 to 1/10,000.

j. Lens: 3.4 mm to 122.4 mm, (F1.6 to F4.5).

k. Optical Zoom: 36X.

l. Digital Zoom: 12X.

m. Video Output: 1.0Vp-p +/- 0.1Vp-p, 75 ohms.

n. Synchronization: Line-lock (-120° - 120° phase adjust) or internal crystal.

o. Signal to Noise Ratio: Greater than 50 dB.

p. White Balance: 2,000 K to 10,000 K.

q. Pan/Tilt Speed: 0.1°/s to 120°/s.

4. Housing modules:

a. Designed as Outdoor Pendant, Environmental version.

b. Housings come standard with recessed setscrews and a recessed bubble latch for increased tamper resistance.

c. Clear bubble outdoor pendant:

i. Use a hinge, in-place of a tether, to make installation easier and safer.

ii. Allow camera to view 18º above the horizon.

iii. Made of cast aluminum for corrosion resistance, and supplied with a built-in heater/blower to provide an operating temperature range down to -40 degrees C to 50 degrees C (-40 degrees F to 122 degrees F). An optional "XT" temperature kit is available to extend the operational range down to -55º C (-67º F).

iv. Type 4X (NEMA 4X) and IP66 certified, rugged, and weather-resistant package.

5. Power supply modules:

   a. Certifications from UL, CE, NEMA-rated.

   b. Operating Temperature: -60° to 50°C (-76° to 122° F).

   c. Humidity: 0% to 100%, condensing.

6. Electrical requirements:

   a. Main supply input voltage:

      i. NTSC: 115VAC, 60Hz.

      ii. NTSC: 24VAC, 60Hz.

      iii. PAL: 230VAC, 50Hz.

      iv. PAL: 24VAC, 50Hz.

   b. Surge Suppression (Protection)

      i. Video: Peak current 10kA (Gas Tube Arrester), peak power 1000 W (10/1000µs).

      ii. Power Input (Dome): Peak current 7.3 A, peak power 600 W (10/1000µs).

      iii. Power Output (Arm Power Supply): Peak current 21.4 A, peak power 1500 W (10/1000µs).

      iv. Alarm Inputs: Peak current 17 A, peak power 300 W (8/20µs).

      v. Alarm Outputs: Peak current 2 A, peak power 300 W (8/20µs).

      vi. Relay Outputs: Peak current 7.3 A, peak power 600 W (10/1000µs).

7. Mechanical requirements:

   a. Pan Range: 360° continuous.

b. Tilt Angle: 18° above horizon.

c. Power: 21 – 30 VAC, 50/60 Hz.

d. Variable Speed: 0.1°/s to 120°/s.

e. Pre-position Speed: Pan: 360°/s Tilt: 100°/s.

f. Preset Accuracy: +/-0.1°.

g. Operating Temperature: -40° to 40°C (-40° to 104° F)].

h. Storage Temperature: -40° to 60°C (-40° to 140° F)].

i. Humidity: 0% to 90% relative non-condensing.

j. Enclosure ratings: Type 4X (NEMA 4X) and IP66.

8. Heating Module:

a. Heater module shall extend temperature range to - 60°C (-76° F).

VSS-6 iSCSI Disk Array

A. General Requirements

1. System overview:

2. The iSCSI Disk Array shall be a full-featured RAID protected disk array which provides advanced RAID-4 protection for capacity-orientated environments and RAID‑DP protection for highest data availability.

3. The iSCSI Disk Array base unit shall provide a maximum of 12 x 1 TB SATA‑II hard disk drives.

4. The iSCSI Disk Array shall offer up to 4 disk shelf expansion units that provide a maximum of 14 x 1 TB hard disk drives each.

5. The iSCSI Disk Array shall offer redundant hot-swap power and cooling, dual Gigabit Ethernet ports, NVRAM, and protection from double-disk failure and single bit errors during RAID rebuilds with RAID‑DP.

6. The iSCSI Disk Array shall offer full SNMP support with agents compatible with SNMP version 1 as well as MIBII and custom MIBs supported.

7. References:

a. Australia and New Zealand Standards :

i. AS/NZS CISPR 22

b. Canadian Standards Association (CSA):

i. CSA 60950, ICES-003.

c. Emissions/Immunity:

i. MIC, VCCI, CoC (South Africa), BSMI, KN22 , KN24, CISPR 24

d. European Norm (CE):

i. Complies with CE requirements.

ii. EN 60950, EN60825-1, EN55022 , EN55024, EN61000-4-2, EN61000-4-3, EN61000-4-4 , EN61000-4-5, EN61000-4-6, EN61000-4-11.

e. Federal Communications Commission (FCC) (www.fcc.gov):

i. FCC Part 15 Class A.

f. International Electrotechnical Commission (IEC):

i. IEC61000-3-2, IEC61000-3-3.

g. International Organization for Standardization (ISO):

i. 9001 – Quality System

h. Safety:

i. CB IEC60950-1 (all national deviations), GOST-R, BSMI CNS14336, CCC GB 4943-2001, SABS, S Resolution 92-98.

i. Underwriters Laboratories, Inc. (UL) (www.ul.com):

i. UL 60950.

8. Definitions:

RAID:

Redundant Array of Independent Disks is a technology that employs the simultaneous use of two or more hard disk drives to achieve greater levels of performance, reliability, and/or larger data volume sizes.

iSCSI:

Internet SCSI is a protocol that allows clients (called initiators) to send SCSI commands

to SCSI storage devices (targets) on remote servers via an IP network.

NVRAM:

Non-volatile random access memory is a type of random access memory which does not lose its information when power is turned off.

SNMP:

Simple Network Management Protocol is a component of the Internet Protocol Suite as defined by the Internet Engineering Task Force (IETF). SNMP is used in network management systems to monitor network-attached devices for conditions that warrant administrative attention.

B. Products:

1. Storage capacity: 6 x 1 TB SATA hard disk
2. Electrical:
   a. Input Voltage: 100 to 120 V (single PSU):
      i. Input current measured: 3.37 A
      ii. Input power measured: 332 W
      iii. Thermal Dissipation: 1,133 BTU/h
   b. Input Voltage: 100 to 120 V (two PSUs):
      i. Input current measured: 3.22 A
      ii. Input power measured: 316 W
      iii. Thermal Dissipation: 1,077 BTU/h
   c. Input Voltage: 200 to 240 V (single PSU)::
      i. Input current measured: 1.69 A
      ii. Input power measured: 327 W
      iii. Thermal Dissipation: 1,114 BTU/h
   d. Input Voltage: 200 to 240 V (two PSUs):
      i. Input current measured: 1.66 A
      ii. Input power measured: 305 W

iii. Thermal Dissipation: 1,039 BTU/h

e. Input Voltage: 100 to 120 V (50 – 60 Hz, single PSU):

i. Input current measured: 3.42 A

ii. Input power measured: 341 W

iii. Thermal Dissipation: 1,163 BTU/h

f. Input Voltage: 100 to 120 V (50 – 60 Hz, two PSUs):

i. Input current measured: 3.22 A

ii. Input power measured: 321 W

iii. Thermal Dissipation: 1,095 BTU/h

g. Input Voltage: 200 to 240 V (50 – 60 Hz, single PSU):

i. Input current measured: 1.63 A

ii. Input power measured: 323 W

iii. Thermal Dissipation: 1,103 BTU/h

h. Input Voltage: 200 to 240 V (50 – 60 Hz, two PSUs):

i. Input current measured: 1.60 A

ii. Input power measured: 309 W

iii. Thermal Dissipation: 1,054 BTU/h

3. Hardware requirements:

a. Chassis: 19-in. rack mountable

b. Power Supplies: Dual redundant, hot pluggable

c. Maximum Disk Drives: 12 x 1 TB SATA-II drives

d. Maximum Net Capacity: ~7000 GB (RAID-4 configuration)

e. DDR2 Memory: 1,024 MB (System RAM)

f. Nonvolatile SDRAM : 256 MB

g. Integrated I/O: 2 x 10/100/1000 Gigabit Ethernet, copper

h. Remote Management via a LAN is supported

i. Power Supplies: Dual redundant, hot pluggable

j. Maximum Disk Drives: 14 x 750 GB SATA-II drives

k. Maximum Net Capacity: ~5700 GB

l. Shelf Connectivity: Fiber channel, copper, and fiber.

4. Environmental Requirements:

a. One Controller Module

i. Operating Temperature: +10°C to +40°C (+50°F to +104°F)

ii. Non-operating Temperature: –40°C to +60°C (–40°F to +140°F)

iii. Relative Humidity: 20 to 80%, non-condensing

b. Disk Shelf Expansion Unit

i. Operating Temperature: +5°C to +40°C (+41°F to +104°F)

ii. Storage Temperature: –40°C to +60°C (–40°F to +140°F)

iii. Relative Humidity: 20 to 80%, non-condensing

c. Operating Acoustic Level: 58 dBA at +23°C

VSS-7 Wireless Radio

A. The wireless transceiver shall be compliant with the following technical specification

1. 2x2 MIMO technology with modulation speed up to 300Mbps.
2. Frequency range: 4.940 – 4.990GHz and 5.17 - 5.850GHz.
3. OFDM modulation (BPSK, QPSK, 16-QAM, 64-QAM)
4. Integrated patch or sector antenna with gain between 14.6 and 17.1dB
5. Transmission power: up to 27dBm
6. IP65 classified enclosure
7. Operating temperature of -30C to + 80C
8. Power consumption: maximum 8W

9. Passive POE power either 15V DC or 24V DC

B. The wireless transceiver shall be capable of transmitting, receiving and forwarding IP packets through the optimal path in real time. The wireless transceiver shall perform a continuous analysis of the bandwidth available on every wireless link. The wireless unit shall be able to detect increases and decreases in link quality in real time, routing packets around low-quality links and sources of interference. The wireless transceiver shall not route packets by minimizing the number of hops in the path but it shall pick the path that provides the lowest latency and highest bandwidth.

C. The wireless transceiver shall be able to support point-to-point, point-to-multipoint, mesh and hybrid network topologies.

D. The wireless transceiver shall be able to support both centralized polling-based and distributed CSMA/CA-based Medium Access Control (MAC) protocols in order to create point-to-point, point-to-multipoint, and mesh architectures.

E. The wireless transceiver shall be capable of supporting up to 150 clients in point-to-multipoint configuration

F. The wireless receiver shall implement an automatic medium access control algorithm that detects the network topology and enables polling-based MAC or CSMA-based MAC.

G. The wireless system shall run on a server-less architecture and shall have a web-base interface for remote management.

H. The wireless network shall be monitored via a web-based management interface.

I. The wireless system shall store up to 30 days log of the main network's parameters: signal strength, modulation speed, throughput, packet error rate and link error rate.

J. The wireless transceiver interface shall provide a build-in spectrum analyzer to scan the frequency spectrum and identify possible source of interference.

K. The wireless transceiver interface shall provide a real time bandwidth monitoring tool

L. The wireless transceiver shall fully support 802.1Q VLAN tagging. It shall support hybrid port-based and MAC-based VLAN tagging.

M. The wireless transceiver shall not be visible to standard 802.11-enabled devices.

N. The wireless transceiver shall prioritize PTZ control packets over video packets to minimize latency and shall be able to transmit IP packets, such as MPEG4 I-frame vs. MPEG-4 P-frame, in different ways, proving different levels of reliability and priority.

O. The wireless transceiver shall provide at least one Ethernet port to interconnect any Ethernet-based devices such as IP cameras, Wi-Fi Access Points, etc.

P. The wireless transceiver shall be able to route and forward multicast traffic.

Q. The wireless transceiver shall be shall be in compliance with the Federal Information Processing Standards (FIPS 197) directive and support 128-bit AES encryption at the link level.

R. The wireless transceiver shall have 2 years warranty in parts and labor.

VSS-8 Ethernet Switch

A. The proposed Ethernet Switch should be an industrially grade extended temperature, fully managed, modular, unit specifically designed to operate reliably in electrically harsh and climatically demanding industrial environments.

B. Physical requirements:

1. 19" Rack Mountable

2. Front or Rear mount

3. Port Capability

4. The number of ports to be provided at each device location shall be the quantity necessary for the successful operation of the Video Security System plus one at minimum additional port of each type for spare capacity at the device location.

5. Operation Temperature -40 degrees C to +70 degrees C

6. No Fans

7. Universal VAC range 85-264VAC

8. Low Voltage Range 10-36VDC and 36-59VDC

C. Virtual local area network:

1. The Ethernet switch will support Virtual local area networks (VLAN) allowing the segregation of a physical network into separate logical networks with independent broadcast domains.

2. A measure of security is provided since hosts can only access other hosts on the same VLAN and traffic storms are isolated.

3. Product will Support 802.1Q tagged Ethernet frames and VLAN trunks as well as Port based classification allowing legacy devices to be assigned to the correct VLAN. GVRP support is also provided to simplify the configuration of the switches on the VLAN is also required.

D. SNMP:

1. SNMP provides a standardized method for network management stations the ability to interrogate devices from different vendors.

2. Product will support SNMP versions v1, v2c, and v3. SNMPv3 in particular provides security features such as authentication, privacy with data encryption (CBC-DES with 56-bit encryption key) and access control not present in earlier SNMP versions.

E. IGMP Snooping

1. Product will support IGMP snooping (Internet Group Management Protocol v1&v2) to intelligently forward or filter multicast traffic streams (e.g. MPEG video) to or from hosts on the network. This reduces the load on network trunks and prevents packets from being received on hosts that are not involved.

2. IGMP Snooping will be enabled on a per VLAN basis. It will Detect and filter all multicast streams regardless of whether subscribers exist. It will Support "router-less" operation by supporting an "active" mode. It will also restore traffic streams immediately after an RSTP topology change.

F. Quality of Service (IEEE 802.1p):

1. Some networking applications such as real-time control or VoIP (voice over IP) and Video, require predictable arrival times for Ethernet frames. Switches can introduce latency in times of heavy network traffic due to the internal queues that buffer frames and then transmit on a first come first serve basis. Ethernet Switch must support 'Class of Service' in accordance with IEEE 802.1p that allows time critical traffic to jump ahead to the front of the queue thus minimizing latency and reducing jitter to allow such demanding applications to operate correctly. Product QoS should allow priority classification by port, tags, MAC address, and IP type of service (ToS). In addition a configurable "weighted fair queuing" algorithm will controls how frames are emptied from the queues.

VSS-9 Surge Protectors

A. General surge protector:

1. The system surge protectors for 10/100baseT should provide protection to equipment connected to the data line. Surge Protectors should be tested to ANSI/IEEE B3 Impulse Standards that exceed normal UL 497B testing standards; the unit should exceed industrial grade surge protection without loading the data line and be self restoring after each surge within ratings.

2. Max. operating voltage: 5 Volts DC or 12 Volts DC

3. Typical Leakage Current: <5u Amps

4. Maximum Data Rate: 120 Mbs

5. Operation Temperature: -40 to +85 C
6. Connectors: RJ45 Male Protected / Female Unprotected
7. Pins Protected: Pins 1 – 8
8. Dimensions: Length: 3” Width: 2” Height: 1 ½” Cat5
9. Max. Surge Current (8x20us): 4,000 Amps Total
10. Max. Surge Voltage (1.2x50us): 6,000 Volts
11. Capacitance: <25 pf
12. Clamping Voltage: 6.8 Volts or 13 Volts
13. Clamping Response Time: <5 Nanoseconds
14. Voltage Sensitive: Non-Load Bearing
15. Pass Voltage Tested to ANSI/IEEE B3: < 10 Volts or <19 Volts Peak
16. Power Dissipation (8x20us): 24,000,000 VA

B. Surge protector for 24VAC:

1. Surge Protector should tested to ANSI/IEEE B3 impulse standards and UL 497B. It should be self restoring after each surge within ratings. These should be designed to protect equipment from nearby lightning and utility power surges, which otherwise would damage or destroy equipment. ANSI/IEEE test standards should be used for performance rating.
2. Max. Operating Voltage: 32 Volts AC
3. Typical Leakage Current: < 5u Amps
4. Maximum Data Rate: 22 Kbs
5. Operation Temperature: - 40 - + 85 C
6. Connection: Dual Terminal Blocks
7. Lines Protected: One Pair
8. Dimension: Depth: 1” – Width: 2” – Length: 1 ½”
9. Tabs: ½” each
10. Install Configuration: In-Line Series

11. Max. Surge Current (8x20us):	10,000 Amps Per line
12. Max. Surge Voltage (1.2x50us):	6,000 Volts
13. Capacitance:	<250 pf
14. Clamping Voltage:	32 Volts AC
15. Clamping Response Time:	<5 Nanoseconds
16. Voltage:	Voltage sensitive
17. Power Dissipation:	60,000,000 VA
18. Pass Voltage (ANSI/IEEE B3 Impulse):	36 Volts AC
19. First Stage Power Dissipation (8x20us):	10,000 Amps

VSS-10 Network Management Software

A. Description:

1.The COMPANY requires that a Video Management Software suite be part of the integrated Solution. The VMS should provide the user with a intuitive, easy to use interface of the security system that enables control, recording and reporting of all functions through varying levels of password protection. The minimum requirements of the system are as follows:

a. The video management system (VMS) specified is an enterprise-class client/server based IP video security solution that provides seamless management of digital video, audio and data across an IP network. The video management system is designed to work as part of a total video security management system to provide full virtual matrix switching and control capability. The video management system consists of the following software modules – the central server, recording services, configuration client, and Operator Clients. Video from other sites may be viewed from single or numerous workstations simultaneously at any time. Cameras, recorders, and viewing stations may be placed anywhere in the IP network.

b. The software components of the video management system are capable of running together on a single PC for small system applications or on separate PCs and servers to meet large systems requirements.

B. Video management system requirements:

1. The video management system (VMS) specified shall be a centrally managed, scalable client/server based architecture that allows full virtual matrix switching and control systems.

2. The VMS shall be designed to use the facility's existing fiber optic and wireless Video IP infrastructure and require no special cabling.

3. The VMS shall provide a built-in command script editor that allows customized command scripts to be written to control virtually all the system functions. Command scripts may be activated by system operators or automatically in response to alarms or system events. The built-in command script editor shall support C#, and VB.NET.

4. The VMS shall provide up to 10 different and independent programmable recording schedules. The schedules may be programmed to provide different record frames rates for day, night, and weekend periods as well as special days. Advanced task schedules may also be programmed that could specify allowed log-on times for user groups, when events may trigger alarms, and when data backups should occur.

5. The VMS shall allow the establishment of user groups that have access rights to specific cameras, priority for pan/tilt/zoom control, rights for exporting video, and access rights to system event log files. Access to live, playback, audio, PTZ control, preset control, and auxiliary commands shall be programmable on an individual camera basis.

6. The VMS shall support Dual Authorization logon. It shall function as follows:

    a. Dual Authorization user groups may be created.

    b. Logon pairs, consisting of any two normal user groups, may be assigned to each Dual Authorization user group.

    c. A separate set of privileges and priorities can be assigned for each Dual Authorization user group.

    d. For each user group assigned as part of a logon pair, it shall be configurable whether the group can:

        i. Log on either individually or as part of the logon pair

        ii. Or log on only as part of the logon pair.

    e. If a user that is part of logon pair logs on individually, then he shall receive the privileges and priorities of his assigned user group. If the same user logs in as part of a logon pair, then the user shall receive the privileges and priorities assigned to the Dual Authorization group to which the pair is assigned.

7. The VMS shall support configuring the Video Analytic parameters from the Configuration Client.

8. The VMS shall react to events triggered by the Video Analytics of the IP cameras.

9. The VMS workstations may be connected to up to four monitors where each monitor may be configured to display live streaming video, playback video, site maps, or alarms.

10. The VMS shall export video and audio data optionally in ASF format to a CD/DVD drive, a network drive, or a USB drive. The exported data in ASF format may be played back using standard software such as Windows Media Player.

11. The VMS shall export video and audio data optionally in its native recording format to a CD/DVD drive, a network drive, or a USB drive. The exported data in native recording format shall include all associated metadata. Viewer software shall be included with the export. Once installed, the viewer software allows playback of the streams on any compatible Windows PC.

C. Video management system components:

1. Central Server software shall provide management, monitoring, and control of the entire system. The central server software should typically be installed on a server-class computer, but may be installed, with all the other video management software modules, on one workstation. The central server shall also maintain data stream management, alarm management, priority management, central logbook and user management.

2. Updates to the Operator Client and Configuration Client shall be automatically deployed from the Central Server.

3. VMS software shall provide recording and playback management of video, audio, and data. VMS software configures the streaming parameters of the assigned devices. The VMS software administers the data on the connected hard disk drives.

4. The VMS shall be designed in such a way the Central Server downtimes do not affect the functionality of the recording services. Normal recording and Motion recording shall continue during the Central Server downtimes, only Alarm Recording cannot be activated as the Central Server is responsible for evaluating the alarm conditions. During Central Server downtime the recording services shall still be able to change the recording parameters schedule dependent.

5. Configuration Client software shall provide the user interface for system configuration and management.

6. Operator Client software shall provide the user interface for system monitoring and operation. The Operator Client maintains live monitoring, storage retrieval, and alarm handling.

D. VMS Failover

1. The VMS shall provide a failover function where a VMS can be assigned as a backup to other VMSs. When an assigned VMS goes out of service the failover VMS takes over the responsibilities of the failed VMS.

E. VMS NVR Redundancy

1. It shall be possible to assign a Redundant VMS NVR to every VMS NVR. The Redundant VMS NVR shall record the same streams as the primary NVR. The primary VMS NVR shall be responsible for configuring the recording qualities in the encoders. The redundant VMS NVR shall have its own disk drives where it shall store the recorded data.

2. It shall be possible to view the data recorded by the Redundant NVR in the Operator Client. The Redundant NVR shall have camera symbols that can be placed in the Logical Tree. These cameras shall have the same name as the cameras of the Primary NVR. An asterisk shall be pre-pended to the camera names of the cameras of the Redundant NVR.

F. Video Recording Manager (VRM)

1. The VMR shall be an optional package of the installation program of the VMS.

2. The video management system shall be capable of managing multiple VRMs.

3. The VRM shall be configured from the VMS Configuration Client. It shall be possible to assign encoded cameras to it

4. The recording parameters shall be configured in the recording tables of the VMS configuration program. These settings will be replicated into the devices from the Central Server.

5. The VRM shall manage the encoded camera, and the ISCSI storage system. It shall offer system wide recording monitoring and management of ISCSI storage, video servers and cameras.

6. The VRM shall support the encoded camera to directly stream the data to the ISCSI storage. The VRM shall not be involved in the processing of the data.

7. The VRM shall manage all disk arrays in the system as a single virtual common pool of storage. It shall dynamically assign portions of that pool to the encoded camera.

8. The transfer rate of the data from IP-Camera is limited by network speed and the ISCSI data throughput rate.

9. The VRM shall provide redundancy for storage provisioning and failover design for central recording management service.

10. The VRM shall provide self healing capabilities to recreate lost databases.

11. The VRM shall provide flexible retrieval of recordings. It shall be able to determine on which ISCSI disk array data from each camera or encoder has been stored.

12. It shall be possible to secure the access to the VRM software with a password. This shall be done in the Configuration Client.

13. The VRM software shall provide status monitoring information as a web interface. The following information shall be provided:

    a. Uptime of the VRM software

    b. Bit rate information for the recorded data

    c. Retention times per camera

    d. Status on recording and storage

G. Network Video Recorder Support:

1. The VMS shall be able to playback data recorded from the encoded camera. This shall include MPEG-2 and MPEG-4 data.

2. The Operator Client shall display live and recorded data from assigned encoded camera. In playback mode the encoded camera shall appear in the graphical timeline.

H. Alarm Management Capability

1. The VMS shall provide the capability to allow alarms to be schedule-dependent.

2. The video management system shall allow alarms to be individually allocated to specific user groups for processing.

3. The video management system shall support replication of events such that a single physical event causes multiple system events. These multiple events shall be independently configurable to allow independent handling of the alarms by multiple operator groups, or to be handled differently according to different schedules.

4. The video management system shall be programmable to selectively, per alarm and per user group, automatically pop-up the alarm video.

5. The video management system shall support display of alarm video in a special Alarm Image Window so users do not have to search their display screens to find the alarm images.

6. The video management system shall display alarm video in rows of Alarm Image Panes, with one row per alarm, and with up to 5 Image Panes per row.

7. The video management system's Alarm Image Panes shall be configurable to display live video, playback video, text documents, site maps, HTML files, or web sites (URLs).

8. The video management system's Alarm Image Pane rows shall be displayed in order of their priority, with rows for higher priority alarms always displayed above lower priority alarm rows. The display order for equal priority alarms shall be selectable between new alarms displayed above existing alarms, or new alarms displayed below existing alarms.

9. The video management system shall provide an alarm reaction time of maximum 2 seconds when sufficient network bandwidth is available.

10. The video management system shall distribute alarm notifications, via entries in the alarm list of the operator user interface, to all members of the user groups to which the alarm is assigned. The alarms shall appear in all said users' alarm lists.

11. The video management system shall operate as follows: when an alarm is accepted by a user, it shall be removed from the other users' alarm lists.

12. The video management system shall allow a user to Un-accept an alarm he has previously accepted. In this case, the alarm shall re-appear in the alarm lists of all members of the user groups assigned to this alarm.

13. The video management system shall support the association of workflows with alarms. Workflows shall consist of action plans and comment boxes. An action plan shall display a text document, HTML page, or web site that typically contains instructions for handling the alarm. Comments entered in the comment boxes shall be logged in the system logbook.

14. The video management system shall be configurable to force an alarm workflow. In this case, the alarm cannot be cleared until the workflow is processed.

15. The video management system shall offer the possibility to automatically clear alarms when the originating event condition is no longer true.

16. The video management system shall allow alarms to be configured to send cameras to prepositions or to execute camera Aux commands on occurrence.

17. The video management system shall be configurable to put any IP-connected camera into alarm recording mode on alarm occurrence.

18. The video management system shall be configurable to send an e-mail or SMS message in response to an alarm.

19. The VMS shall be capable of displaying video on analog monitors connected to video decoders in response to alarms.

20. The VMS alarm response shall take advantage of the row and column arrangement of analog monitor groups by associating a row of analog monitors with each active alarm. Each alarm may display video on multiple monitors, limited by the number of columns in the analog monitor group.

21. As new alarms are received, alarm rows shall stack in priority order on the analog monitors.

22. The VMS shall support alarm may display video on multiple analog monitor groups, with configurable assignment of individual assignment of alarms to monitor groups.

I. Relays and Digital Inputs:

1. The open/close states of inputs and relays from devices connected to the system, including IP cameras shall be indicated on the VMS Operator Client user interface and can be queried via the VMS SDK.

2. Relays from devices connected to the system shall be controllable from command scripts, the VMS SDK, and icons on the Operator Client user interface.

3. Input and relay state changes from devices connected to the system shall be recognizable as events in the VMS.

J. Logbook

1. The system shall protocol every event and alarm in an SQL database. The alarm entry shall contain the camera titles that have been recorded due to this alarm.

2. The logbook shall be able to store at least 500,000 entries per hour. If the capacity of the logbook is filled up the oldest entries will be deleted to create space.

3. The user shall be able to search the logbook for events and alarms. The user shall be able to export the search results into a comma separated value list (CSV).

K. SNMP:

1. The video management system shall be capable of monitoring 3rd party equipment SNMP protocol.

L. Pre-Programmed Camera sequences:

1. The video management system shall support pre-programmed camera sequences. These sequences will allow cameras to be automatically displayed on the computer image panes and/or analog monitors connected to decoders. The sequences shall support simultaneous display on multiple image panes or monitors. The sequences shall also support camera prepositions for each camera on each sequence step. The system shall be configurable such that operators can select these sequences from the logical tree or a site map.

M. Command Scripts:

1. The video management system shall provide a command script interface that allows system operations to be programmatically controlled.

2. The system shall provide a built-in editor for the creation of the command scripts.

3. The system shall be configurable such that operators can execute the created scripts by double-clicking on representative icons in a logical tree or site map.

4. The system shall be configurable such that the created scripts can be executed automatically in response to a system event. The automatic event-driven execution shall optionally be schedule-dependent.

5. The system shall be configurable to execute a user-group dependent command script on user logon.

6. The system shall be configurable to execute an alarm-dependent command script on user acceptance of the alarm.

N. Virtual Inputs:

1. The video management system shall provide a software interface that allows third-party software to generate events in the video management system. The software shall support any COM programming languages (e.g. Visual Basic and C++), any .Net programming language (e.g. C#) or JavaScript.

2. The VMS shall allow third-party software to include up to 10 data fields and an Alarm ID along with the virtual input event.

3. These fields shall be searchable in the system logbook.

4. The virtual input data shall be optionally displayed in the Operator Client playback mode synchronously with the associated video.

O. Software development kit (SDK):

1. The video management system shall provide a documented Software Development Kit (SDK) to allow integration with third-party software.

2. The SDK shall expose all functionality of the command scripts, including, for example:

   a. Control of operator workstation image window layout

   b. Sending messages to specific workstations

   c. Assignment of cameras, documents, URLs, and maps to Operator Client workstation image panes

d. Assignment of cameras to analog monitors connected to encoders.

e. Dome control

f. Alarm generation

g. Recording mode control

h. Exporting recorded data

i. Relay control

3. SDK functionality shall be password protected.

4. The SDK shall be accessible from all .Net programming languages.

P. OPC Interface:

1. The VMS shall provide an OPC Server for integration into third-party software systems, such as building-management systems.

2. The OPC interface shall follow the OPC Alarms and Events standard.

Q. Configuration Changes:

1. Configuration changes made in the VMS Configuration Client shall modify a working copy of the configuration, and shall not affect the active operating configuration.

2. It shall be possible to activate the working copy through a user action in the Configuration Client, at which point the working becomes the new active operating configuration.

3. It shall be possible to view a list of all configuration activations that have been applied to the system. It shall be possible to select any of the activated configurations, and have the system "roll back" to an earlier configuration.

R. Operator Client:

1. This section describes the functionality common to “Operator Client VRM” and “Operator Client NVR”

2. The video management system shall provide an administrator-configured Logical Tree. The logical tree shall be freely configurable with any tree structure, with nodes consisting of folders or maps, and leaves consisting of devices (cameras, inputs, and relays), sequences, documents, URLs, or command scripts. Each user group shall only see items in the logical tree for which the administrator has granted access.

3. The user shall be able to search the logical tree for item names.

4. The video management system shall provide a user-dependent Favorites Tree. The Favorites tree shall allow maps, folders, and devices and complete views (image pane patterns with camera assignments) to be configured by each user in a user-defined structure. The user's favorites tree shall be available irrespective of the computer with which he logs on to the system.

5. The video management system shall provide an Image Window that displays a collection of Image Panes. The number of image panes per image window shall be variable between 1 (a single full-window video) and 25, arranged in a 5x5 grid. A slider shall be available allowing the grid size to be changed from 1, 2x2, 3x3, 4x4, and 5x5. The VMS shall allow image panes to be enlarged or decreased in size within the grid. E.g., in a 5x5 grid, a single image pane can be enlarged to use 4 of the grid elements, creating a larger image within the grid. Any pattern can be created within the grid structure. An image pane can be resized by clicking and dragging on any corner, dragging the corner to the desired size.

6. The video management shall implement the concept of a selected image pane. The selected image pane is marked by a yellow border. There shall always be a selected image pane in the Operator Client application. The selected image pane is always used for control commands, e.g. PTZ control, instant playback control, audio replay.

7. The video management system shall support site maps with hot-spot icons for devices (cameras, relays, and inputs), command script initiation, camera sequence initiation, and links to other site maps. The site maps shall be capable of being zoomed. The hot-spot icons representing devices that can generate alarms shall blink when a corresponding alarm is generated. The hot-spot icons shall be configurable to optionally display the device name or link title.

8. The Operator Client shall display live streams encoded camera. It shall be possible to select which encoding stream (Stream 1 or Stream 2) of the camera shall be displayed.

9. The video management system shall support automatic sequencing. It shall be possible for users to multiple-select cameras (control-click or shift click), and drag the multiple-selection to an image pane or a graphic representing an analog monitor. All of the cameras in the selection shall then sequence in the image pane or monitor at a user-selectable rate. It shall also be possible to drag a folder to an image pane or analog monitor. In this case, all of the cameras contained within the folder shall sequence.

10. The video management system shall support PTZ control with a dedicated graphical joystick control. It shall also support PTZ control via clicking the mouse in the image panes. For PTZ cameras, the cursor shall change to indicate the Pan/Tilt direction when hovering over the corresponding image pane. The Pan/Tilt speed shall increase as the cursor moves farther from the center of the image pane. An area in the center of the image pane shall be used for zoom-in/zoom-out control. Once zoom is

initiated, the zoom speed shall increase as the cursor is moved farther from the center of the image pane.

11. The video management system shall support digital zoom of any image pane. A dedicated graphical control shall be provided in the user interface for this purpose. In addition, the mouse wheel shall control digital zoom when the mouse cursor is hovering over a selected image pane.

12. The video management system shall provide an Instant Playback function that displays recorded images on one or multiple image panes. Recorded images from a single camera may also be played back on multiple panes. Instant playback supports pause, play forward, play reverse, single step forward, single step reverse, fast-forward, and fast-reverse.

13. The video management system shall support a timeline that provides a graphical overview of video stored on the disk. The timeline shall display a timescale that can be adjusted from at least 15-minutes per division to 1 month per division. For each camera displayed in playback mode, the timeline shall provide a line that depicts the video storage for that camera. The line shall be color-coded to show if video is recorded for the displayed time period, and if so, if it is normal recording, motion recording, or alarm recording. The line shall be cross-hatched if the video is protected from deletion. The line shall also indicate if associated audio is recorded during the displayed time period.
    The video management system shall support simultaneous time-synchronous playback of up to 16 cameras. Playback shall support single-step forward and backwards; play normal speed forward and backwards; play high-speed forward and backwards; and play slow-speed forward and backwards.

14. The video management system shall support search of recorded video for motion in user-specified areas of a camera image.

15. The video management system shall support search of recorded video with at least the following criteria: object size, object color, direction, and speed as well as detecting objects entering or leaving designated areas. This Intelligent Video Analytics (IVA) based post-recording search will work for cameras assigned to the VMS.

16. The video management system shall optionally display the information of the video analytics such as cells with detected motion, object masks, and trajectories.

17. The video management system shall support searching based on any combination of time/date-rage, event type(s), alarm priority, alarm state, and device(s). It shall be possible to save and recall search parameters.

18. The video management system shall graphically display device states on its icons in the logical tree structure and on sitemaps. For cameras, the states shown shall include: loss of the analog video signal, network connection loss, video signal too noisy, video signal too bright, video signal too dark, video de-adjusted, and video

includes associated audio. For relays and contact inputs, the open or close state shall be indicated.

19. The video management system shall support switching of cameras to analog monitors connected to decoders. The cameras shall be selectable via drag and drop from the logical tree or from the sitemaps.

VSS-11 Video Surveillance Monitory and Supervisory

A. General:

1. Intelligent video analysis (IVA) is an automated real-time software solution that continually and accurately analyzes incoming video against a predefined set of rules to detect and notify appropriate personnel of violations and abnormal events.

2. Video content analysis (VCA) refers to the systematic evaluation of video for significant features within a series of frames.

3. Motion Detection refers to detecting a moving object in a video sequence.

4. Recording at the Edge is the concept of taking audio/video from a camera and storing it at the "edge" of the Ethernet network - instead of transporting it across the network to a centralized recording facility such as a network video recorder.

5. Video over IP is the transmission of digital video via a PC display over an IT infrastructure with the use of a server and network storage.

6. An IP Camera is a conventional analog camera with an embedded encoder that directly generates an IP video stream.

B. References

1. International Organization for Standardization (ISO) (www.iso.ch)

   a. ISO 9001 – Quality Management Systems.

2. Underwriters Laboratories, Inc. (UL).

3. Federal Communications Commission (FCC).

C. Video Surveillance Monitoring and Supervisory Interfaces:

1. Intelligent Video Analysis (IVA)

   a. Licensed embedded advanced video motion and content analysis option.

   b. Functions as an automated guard assistance system.

   c. Uses predefined rules to detect behavior of objects.

d. Provides operator alerts.

e. Tamper detection.

f. Delivers metadata information in both live and stored video.

g. Intelligence at the edge.

D. Performance Requirements

1. Reliably detect, track and analyze moving objects while suppressing unwanted alarms from spurious sources in the image.

2. Filter out irrelevant areas to increase sensitivity of critical areas.

3. Size, speed, direction and location discrimination to prevent false alarms.

4. Background learning algorithm to automatically adapt to changing environmental conditions such as rain, snow, and tree movement.

5. Independent configurable detector areas for alarm generation.

6. Graphical camera calibration utility for perspective correction.

7. Generates metadata for real-time and forensic analysis.

8. Embedded in cameras.

E. System Architecture

1. The system will be comprised of software for IP cameras with video content analysis (VCA) capability for the device.

2. It will not require any additional hardware, such as PC's or Analysis Servers, to perform the video content analysis (VCA).

3. The failure of a single or multi-channel VCA device will only result in the loss of content analysis for that one device. All other VCA devices will continue to operate and provide video content analysis.

4. Each IP camera will contain its own set of rules for VCA detection. The user will be able to configure the rules. It will be possible to upload the configuration file locally or centrally to a PC for backup.

5. Each IP camera will embed the VCA data in the form of metadata and transmit it together with the video. The video and metadata will be stored together.

6. The design of the system will make expansion of VCA capability to other cameras simple. All IP cameras installed in the system will be equipped with VCA capability;

it will only be required to input a license string to the device, via internet browser or configuration software, to enable the feature. Systems that require additional equipment, such as PC's or Analysis Servers, will not be acceptable.

F. System Features

1. Adapts to changing lighting and environmental conditions such as rain, snow and wind-blown leaves.

2. Built-in image stabilization to remove jitter from shaking video sources such as cameras mounted on poles.

3. Built-in tamper monitoring that detects camera hooding or masking, blinding, defocusing, and repositioning.

4. Support for Far Infra Red thermal cameras to detect and track objects.

5. Configurable sensitive areas to monitor areas of interest with advanced tracking capability and alarm management.

   a. Configurable detection items include:

      i. Up to 16 fields composed of polygons that cover a certain area

      ii. Up to 16 lines for virtual trip wires with triangles that indicate the direction an object must cross to trip an alarm.

      iii. Up to 8 routes with direction triangles to trigger an alarm event.

   b. Configurable condition filters include:

      i. Size (max/min) of objects. Other objects will be ignored.

      ii. Aspect ratio (vertical/horizontal) to aid in object specification and classification.

      iii. Direction of travel to generate an alarm. Can be one-way or two-way.

      iv. Speed (min/max) of objects moving to generate an alarm.

      v. Color of object that will trigger an alert.

   c. Configurable tasks include:

      i. Alarm rules that define what event, or combination of events, will trigger an alarm.

      ii. Up to eight (8) alarm tasks per camera are available. Each alarm task can be evaluated separately to differentiate alarm priority, combine certain condition

sequences to trigger alarms, and create complex rules to manage alarm scenarios.

6. Detect behavior of objects, tracks and analyzes moving objects while suppressing false alarms.

   a. Detect entering, leaving, or moving within a specified area.

   b. Detect idle and removed objects.

   c. Detect speed of objects.

   d. Detect behavior such as loitering of objects.

   e. Detect single or multiple line crossings for perimeter intrusion detection.

   f. Detect changes in object properties, such as size, aspect ratio, speed and direction, within a specified time span.

   g. Detect direction of objects.

   h. Behaviors can be combined with other rules.

7. Provide forensic search capability of recorded video to reduce time, cost, and effort.

   a. Supports all IVA detection items, filters, alarm tasks, and configuration wizards.

8. User definable rules:

   a. The user will be able to combine multiple rules to form complex detection scenarios.

   b. Both a script based alarm task editor and a simplified guided Alarm Task Wizard will be available to the user.

9. All above features will be embedded into the encoded camera. No additional PC hardware is necessary.

10. A single license will cover all the above features. No additional licenses are required.

G. Configuration Software Features

1. The software will allow in scene camera calibration for perspective correction using 3D grid.

2. There will be flexible selection of active areas and tasks.

3. The software will provide a graphical wizard utility to define the events, or combination of events, that will trigger an alarm.

4. A GUI based wizard will allow with simple "click-on-object" selection that automatically gathers relevant object data, such as size, aspect ratio, speed and color to be used in the rules configuration.

5. There will be a built-in utility that constantly gathers statistics on relevant detected objects to help refine the filtering criteria for event detection.

H. Forensic Search Capability

1. The system will be equipped with forensic search capability to search through video recordings for user specified events.

2. The forensic search will utilize metadata recorded to find the user specified event.

3. It will be possible for the user to change the rules or create new rules to detect events that were not detected during live operation. For example, even if the live system was not configured for "removed object" detection, it will be possible to configure the forensic search to detect such events later using the recorded video.

4. All workstations in the system will be capable of performing forensic searches.

5. It will be possible to export the picture of the forensic search result into a JPEG image.

I. Execution:

1. Protect devices from damage during construction.

2. Install software in accordance with manufacturer’s installation instructions.

3. Install main program on dedicated platform.

4. No additional web servers or application may be installed on the platform.

5. Accept defaults for target directories prompted during installation.

6. Test proper operation of software programs in each workstation.

7. Test proper operation of host system.

VSS-12 IP Video Encoder

A. The IP encoder shall be an industrial grade, high-performance, single or dual, input CCTV video encoders.

B. The product will be constructed to withstand extreme environmental conditions, operating from -30 °C to +60 °C (-22 °F to +140 °F).

C. The IP Encoder will provide Dual Streaming to generate two independent IP video streams per channel. This allows viewing and recording at two different quality levels to save disk space and bandwidth. On alarm, the IP Encoder will be able to send an e-mail with JPEG images attached.

D. The IP Encoder will support H.264 to encode the video signal. This allows for reducing the required bit rate for a given quality setting, or increasing the quality when keeping the bit rate setting.

E. Video Support for up to 2 Analog Ports.

F. Connector and Impedance, BNC: 75 Ohm Switchable.

G. Analog Signal composite: 0.7 to 1.2 Vpp, NTSC or PAL

H. Ethernet support for dual port 10/100 Base-T, auto-sensing, half/ full duplex, RJ45

I. Ethernet Protocol Support of RTP, Telnet, UDP, TCP, IP, HTTP, HTTPS, FTP, DHCP, IGMP V2/V3, ICMP, ARP, RTSP, SMTP, SNTP, SNMP (V1, MIB-II), 802.1x

J. Physical Dimensions not to exceed 61 x 160 x 178 mm (2.4 x 6.3 x 7.01 in)

K. Weight not to exceed 1.5 kg (3.3 lb)

L. Frame Rates:

1. 2CIF 704 x 288/240 (25/30 ips)
2. 2/3D1 464 x 576/480 (25/30 ips)
3. 1/2D1 352 x 576/480 (25/30 ips)
4. CIF 352 x 288/240 (25/30 ips)
5. QCIF 176 x 144/120 (25/30 ips)
6. Encoding Standards
    a. H.264 Baseline Profile (ISO/IEC 14496-10) MPEG-4, M-JPEG, JPEG.
7. Camera control
    a. Will support full camera control capability (PTZ) utilizing Pelco –D protocol

VSS-13 IP-Based Power Reset Switch

A. The IP based Power Reset Switch will be used to individually power cycle the components within the equipment cabinet at each location. At a minimum this unit will be required to power cycle the Analog Camera, IP Encoder, encoded camera (if

applicable) and Wireless Radio (if applicable). This unit will also be required to ping the IP electronics within the cabinet to verify a "heartbeat" for each device within the cabinet and support scripting to enable power cycling of any device that stops responding to ping within a user defined predetermined amount of time.

B. Ethernet Interface shall be 10/100 autosensing, Static IP, TCP port selectable, 8 pin RJ-45 with internal FCC filtering.

C. Input Voltage: 8-24V, AC/DC Autosensing

D. Input Frequency: AC or DC, 0-400Hz

E. Auxiliary Power Out: +5 VDC 250mA Regulated

F. Power Dissipation: 12W Max

G. Case Contact Rating: 300V, 6A continuous, 10A peak

H. Relay Contact Rating: T-90, 277V, 15-25A AC/DC, 1/2HP

I. Password Transmission: Encrypted, base 64 Movable HTTP security port

J. Circuit Breaker: Auto-reset thermal on +5V out

K. Power Fail Hold-Over: 600ms minimum

L. Programmable power-Up Settings: Last settings, all relays off, sequential on

M. Weight 2.7 lbs

N. Software controls (via web or script):

1. Individual outlets on/off, all on/ off, network settings, web links, outlet and relay names, multiple power-on modes for safety. Internal scripting language.

O. Dimensions: Not to exceed 8"X4"X6"

P. Operating Temperature: -40 Degrees to 170 Degrees F, -34Degrees to 77 Degrees C

VSS-14 Equipment Cabinet

A. The equipment cabinet that will house the field equipment located in the Intermodal Yard will be a pole-mount enclosure designed to house and protect electrical and electronic components in industrial environments. It will provide traditional enclosure functionality with scalable internal component mounting capability using a 19" rack mounting system and accessory components.

B. The cabinet will be manufactured to the following standards:

1. NEMA/EEMAC Type 4, 12, 13
2. CSA File No. 42186: Type 4, 12
3. IEC 60529, IP66

C. The Equipment cabinet must provide the following features:

1. Galvanized steel front and back vertical accessory mounting rails to mount equipment that requires a 19" wide opening.
2. Galvanized steel half-height back panels for mounting equipment along the sides of the cabinet as required
3. Galvanized steel full-height side panels for mounting equipment along the side of the cabinet as required
4. Galvanized steel side mount accessory rails for mounting DIN rail compliant equipment as required.
5. Galvanized steel horizontal separator mounts onto side-mount accessory rails to provide a support shelf to house the external batteries if required to support the Video system for 6-hours.
6. A key locking handle for security. The padlocking handle should accommodate up to a 5/16-in. diameter padlock shank. Each latch system will be convertible from clockwise to counter-clockwise to accommodate reversible openings. Key locking handle must maintain IP66 and UL/CSA Type 4 and 12.
7. Equipment cabinet shall have two (2) doors for accessibility.
8. Equipment cabinet will be mounted on a circular concrete pylon.
9. Equipment cabinet will be equipped with a Thermostatically controlled fan and a filter to circulate air within the cabinet.
10. Pull-out shelf for laptop and maintenance use.
11. 2 fluorescent lights with a door switch.
12. 120 VAC ground fault interrupted (GFI) protected duplex outlets for tools.
13. 120 VAC transient voltage surge suppression (TVSS) protected duplex outlets for equipment.
14. Exterior Ethernet Port and Receptacle mounted in the door of the cabinet:

a. The external RJ45 and power receptacle is required to provide access to the electronics housed within the equipment cabinet, without the requirement to open the cabinet door.

b. The Receptacle should be weathertight and have the capability to be locked using a removable padlock. The cover plate should use a pressure latch that utilize a rubber seal sufficient to seal the receptacles (RJ45 and 120VAC) against the elements.

c. The Ethernet connector in the receptacle should be wired to a 10/100M port of the ethernet switch inside the cabinet.

d. The 120VAC plug should be wired to the AC source and surge protected.

e. The Receptacle should be mounted in the center of the cabinet from left to right and as low as possible and still allow for the cabinet door to swing open and close freely.

f. The 120VAC receptacle should be grounded and the cabling connecting the receptacle to the AC power source and the ethernet switch should be dressed in such a way as to eliminate any binding, pinching or crimping of the cables that could cause a cable fault.

15. The cabinets shall be sized to ensure ease of access to equipment and provided with proper ventilation to maintain an internal operating environment that does not exceed the environmental operating ranges for devices placed within the cabinet. Furnish all materials with the most recently developed and approved product versions that meet or exceed all applicable standards, specifications, and requirements before the system is considered for acceptance. Each cabinet assembly shall also include any ancillary equipment or incidental items, such as required mounting hardware and cabling.

D. Construction:

1. The cabinet shall have maximum dimensions: 36 in H x 32 in W x 16 in D unless otherwise shown on the Plans.

2. The cabinet and doors shall be fabricated of 0.125-inch minimum thickness aluminum.

3. All exterior seams for the cabinets and doors shall be continuously welded. Exterior welds shall be ground smooth. Edges shall be filed to a radius of 0.03-inch minimum. To meet the requirements of these specifications a maximum of (2) cabinets can be provided at each device location.

E. Handle and lock:

1. When the door is closed and latched, the door shall be locked.

2. The handle shall have a minimum length of 7 inches (180 mm) and shall be provided with a 5/8–inch (16-mm), minimum, steel shank. The handle shall be fabricated of cast aluminum or of zinc-plated or cadmium-plated steel.

3. Cabinet locks shall be the solid brass and keyed to a master key tumbler rim type approved by the ENGINEER. The lock shall have rectangular, spring-loaded bolts. The locks shall be left- or right-hand as applicable, and rigidly mounted with stainless steel machine screws approximately 2 inches (51 mm) apart. The locks shall have a cover plate for protection from the elements.

4. Keys shall be removable in the locked and unlocked positions, and two keys furnished with each cabinet. The front position of the lock shall extend 1/8 inch to 3/8 inch beyond the outside surface of the door.

5. The cabinet doors shall also be pad lockable.

F. Doors:

1. All cabinets shall have two full-size doors.

2. Pole mounted cabinets shall be designed so mounting brackets can be installed on the side so both doors are fully functional.

3. The doors shall be provided a full-length stainless steel piano hinge, with stainless steel pins spot-welded at the top. The hinges shall be mounted so that they cannot be removed from the door or cabinet without first opening the door. The hinge side of the doors shall be located on the part of the cabinet near the pole.

4. The door and hinges shall be braced to withstand a 100-pound per vertical foot of door height load applied vertically to the outer edge of the door when standing open. There shall be no permanent deformation or impairment of any part of the door or cabinet body when the load is removed.

5. The door opening shall be double flanged on all four sides. Doorstops shall be included at 90 and 180-degree positions.

6. The catches shall be 3/8 inch diameter, minimum, plated steel rods. The catches shall be capable of holding the door open at 90 degrees in a 60 mph wind at an angle perpendicular to the plane of the door.

7. Both the door and the doorstop mechanism shall be of sufficient strength to withstand a simulated wind load of 5 pounds per square foot of door area applied to both the inside and outside surfaces without failure, permanent deformation, or compromising of door position and normal operation.

8. The cabinet door frame shall be designed so that the latching mechanism will hold tension on and form a firm seal between door gasket and door frame.

9. The latching mechanism shall be a 3-point cabinet latch with nylon rollers. The center catch and pushrods shall be zinc-plated or cadmium-plated steel. Pushrods shall be turned edgewise at the outer supports and shall be 1/4 x 3/4 in. minimum. The nylon rollers shall have a minimum diameter of 3/4 inch and shall be equipped with ball bearings.

G. Gaskets:

1. Ensure that cabinet doors include a gasket to provide a dust and weather-resistant seal when closed.

2. The gasket material shall be closed-cell neoprene and shall maintain its resiliency after exposure to the outdoor environment.

3. The gasket shall show no sign of rolling or sagging, and shall ensure a uniform dust and weather resistant seal around the entire door facing.

4. Gasket shall be provided on all door openings and shall be dust-tight.

5. Gaskets shall be permanently bonded to the metal. The mating surface of the gasket shall be covered with a silicone lubricant to prevent sticking to the mating surface.

6. All overlapping exterior seams and doors shall meet the requirements for Type 4 enclosures in the National Electrical Manufacturers Association (NEMA) enclosure standards.

H. Mounting:

1. All pole mount cabinets shall include all necessary components required for secure connection to any pole including but not limited to the pole mounting brackets and mounting hardware. The mounting height shall result in the bottom of the cabinet at minimum 6” above the ground.

I. Shelves:

1. Substantial metal shelves or brackets shall be provided to support equipment.

2. Machine screws and bolts shall not protrude beyond the outside wall of the cabinet.

J. Coating:

1. All coatings shall be commercially smooth, substantially free of flow lines, paint washout, streaks, blisters and other defects that would impair serviceability or detract from general appearance.

2. All cadmium plating shall conform to the requirements in Military Specification MIL-QQ-416b. All zinc plating shall conform to the requirements in Military Specification MIL-QQ-325b.

K. Ventilation:

1. Cabinets shall be provided with vent openings in the front door to allow convection cooling of electronic components.

2. Each cabinet shall be equipped with an electric fan with ball or roller bearings and a capacity of at least 100 cubic feet per min.

3. The fan shall be thermostatically controlled and shall be manually adjustable to turn on between 89.6 °F (32 °C) and 149 °F (65 °C) with a differential of not more than 10.8 °F (6 °C) between automatic turn on and turn off.

4. The cabinet fan circuit shall be fused at 125 percent of the ampacity of the fan motor installed.

5. The manual adjustment shall be graded in 18 °F (10 °C) increments.

6. The vent opening shall be located on the lower portion of the cabinet door and shall be covered fully on the inside with a commercially available disposable three layer graded type filter.

7. Removable air filter shall be housed behind the door vents. The filter filtration area shall cover the vent opening area. A filter shell shall be provided that fits over the filter, providing mechanical support for the filter.

8. The shell shall be louvered to direct the incoming air downward.

9. The shell sides and top shall be bent over a minimum of 0.26 inches to house the filter.

10. The filter and shell shall be held firmly in place with a bottom bracket and a spring-loaded upper clamp. No incoming air shall bypass the filter.

11. The bottom filter bracket shall be formed to create a waterproof sump with drain holes to the outside housing. The filter shall trap particles 2 microns and larger.

L. Wiring:

1. Conductors used in cabinet wiring shall be No. 22, or larger, with a minimum of 19 strands. Conductors shall conform to Military Specification MIL-W-16878D, Type B or better.

2. The insulation shall have a minimum thickness of 10 mil (254μm) and shall be nylon jacketed polyvinyl chloride or shall be irradiated cross-link polyvinyl chloride, polyhalocarbon or polychloro-alkene, except that, at the Contractor's option, conductors No. 14 and larger may be Underwriters Laboratories Incorporate (UL) Type Thermoplastic High Heat Resistant Nylon Coated (THHN). Conductor insulation shall be rated at 300 Volts (V) and shall be rated for use at 221 °F (105 °C).

3. Cables shall be provided with strain relief.

4. Wiring within cabinets shall be neatly arranged and laced, or enclosed in plastic tubing or raceway.

5. Conductors used in cabinet wiring shall conform to the following color-code requirements:

    a. The grounded conductor of a circuit shall be identified by a continuous white or natural gray color.

    b. The equipment grounding conductor shall be identified by a continuous green color or by a continuous green color with one or more yellow stripes.

    c. The ungrounded conductors shall be identified by any color not specified in 1or2 above.

6. Conductors used in cabinet wiring shall terminate with properly sized captive or spring spade type terminals or shall be soldered to a through-panel solder lug on the rear side of the terminal block. Crimp-style connectors shall be applied with a proper tool which prevents opening of the handles until the crimp is completed.

7. Equipment grounding conductor bus shall be provided in each cabinet. The bus shall be grounded to the cabinet and shall be connected to the metal conduit system or other approved ground with a Number 8, or larger, grounding conductor.

    a. With all the cabinet equipment in place and connected, the resistance between the grounded conductor terminal bus and the equipment grounding conductor bus shall be 50 MegaOhms, minimum, when measured with an applied voltage of 150 volts-direct current (VDC).

    b. If direct current (DC-) is to be grounded, it shall be connected to equipment ground only. Two or more terminal blocks shall be provided for field connections.

    c. Field terminals shall be installed within 22 inches (560 mm) of the face of the cabinet and shall be oriented for screwdriver operation from the door opening. All terminals shall be a minimum of 5 inches above the foundation.

    d. No more than three conductors shall be brought to any one terminal.

    e. Two flat metal jumpers, straight or U shaped, may also be placed under a terminal screw. At least two full threads of all terminal screws shall be fully engaged when the screw is tightened. No live parts shall extend beyond the barrier.

8. Field connection shall be made for the conductors of signal cable, power cable, interconnect cable and wireless cable. Conductors shall be connected so the outgoing circuits shall be of the same polarity as the line side of the power supply. The circuit common return shall be of the same polarity as the ground side of the power supply.

The grounded side of the power supply shall be grounded to the cabinet in an approved manner. All field wiring shall be neatly arranged and routed to the appropriate terminal blocks.

9. Field wiring entering the cabinet except power wiring shall be fitted with spade terminals to assure a good connection. Incoming power wiring may use space terminals; or the bare conductor wire may be connected to terminal points utilizing screw or spring applied clamping surfaces compatible with either copper or aluminum wire and providing a positive grip. After completion of field wiring, the conduit entering the cabinet shall be completely sealed in an approved manner with a removable sealing compound or a molded plastic or rubber device, which is compatible with the cable jacket, the insulation and the conduit material.

M. Labels:

1. All equipment in the cabinet shall be permanently and clearly labeled.

2. A permanent printed, engraved or silk screened label shall be provided for all removable items of equipment such as, receptacles for relays, switching devices, switches, fuses, and circuit breakers.

3. Labels shall conform to the designations on the cabinet wiring diagram.

4. Labels for all shelf-mounted equipment shall be on the face of the shelf below the item.

5. Labels for wall-mounted equipment shall be below the item.

6. The marker strips shall be made of material that can be easily and legibly written upon using a permanent marker. Marker strips shall be located immediately below the item they are to identify and must be clearly visible with all items installed.

N. Convenience Receptacle:

1. Two convenience receptacles shall be mounted in readily accessible locations inside the cabinet.

2. Convenience receptacles shall be duplex, 3-prong, NEMA Type 5-15R grounding type outlet and shall conform to the requirements in UL Standard 943.

3. All receptacles shall be wired through the cabinet surge arrestor.

O. Lighting Fixture:

1. Each cabinet shall be provided with two fluorescent lighting fixtures mounted at the top of the cabinet, one near each of the doors.

2. Fixture shall be provided with a F-15-T-8 cool white lamp operated from the 120 VAC power supply, UL listed ballast.

3. A door-activated switch that turns both lights on when either door is opened and off when doors are closed shall be installed.

P. Terminal Blocks:

1. Terminal blocks shall be rated 600 VAC, minimum, and shall be provided with nickel, silver or cadmium plated brass binder head screw terminals. Heavy duty terminal blocks shall be rated at 20 A and shall be provided with twelve poles with Number 10 x 5/16 in. nickel plated brass binder head screws and nickel plated brass inserts. Each pole position shall be provided with two terminal positions. The terminal blocks shall be the barrier type, with shorting bars in each of the twelve positions, and shall be provided with integral type marking strips. Light duty terminal blocks shall be rated at 5 A and shall be provided with twelve poles with Number 6 x 1/8 in binder head screws. Each pole position shall be provided with one terminal position.

Q. Pullout Drawer Assembly:

1. A pullout drawer shall be installed in the cabinet cage. The drawer shall be 16.92 inches long by 16.92 inches wide by 1.73 inches deep.

2. It shall have a hinged top that covers the storage box area and also provides a smooth surface to write on.

3. The top of the storage compartment shall be aluminum.

4. The compartment shall have ball bearing telescoping drawer guides to allow full extension from the rack assembly.

5. When extended, the storage compartment shall open to provide storage space for cabinet documentation and other miscellaneous items.

6. The storage compartment shall be of adequate construction to support a weight of 20 pounds (9 kg) when extended without sagging.

7. A plastic envelop with resealable opening shall be in each drawer to provide protection for cabinet and site detailed drawings. The size of the envelopes shall be big enough to accommodate the above drawings.

R. Toggle Switches:

1. Toggle switches shall have poles as required and shall be rated at 200 percent of circuit current for circuits of 10 A or less and 125 percent of circuit current for circuits over 10 A.

2. Circuit breakers used as toggle switches shall be UL or Electrical Testing Laboratory (ETL) listed for switching operation.

S. Cartridge Fuses:

1. Cartridge fuses shall be installed in panel mounted fuse holders. Fuse type and rating shall be as recommended by the fuse manufacturer for the type of load being protected.

T. Circuit Breakers:

1. Circuit breakers shall have a minimum interrupting capacity of 5000 A, root mean square (RMS).

U. Connectors:

1. Connectors used for interconnecting various portions of circuits together shall be designed and constructed for the application involved.

2. Connectors shall be designed to provide positive connection of all circuits, and easy insertion and removal of mating contacts.

3. Connectors shall be permanently keyed to prevent improper connection of circuits.

4. Connectors, or devices plugging into connectors, shall be provided with positive means to prevent any individual circuit from being broken due to vibration, pull on connecting cable or similar disruptive force.

V. Cabinet Insulation:

1. The interior of the cabinet shell and doors shall be fully lined with 3/4 extruded polystyrene insulation sheeting, except for structural ribs, vents and fan openings, lock linkages, shelf brackets and other necessary functional areas.

2. Sheeting shall have a minimum R value of 3.75.

W. Environmental:

1. The components such as fluorescent lighting, surge suppressors and power distribution shall operate properly within the ambient temperature limits of 0 °F (-17.8 °C) to 120 °F (48.9 °C) and meet the ambient temperature range, relative humidity, applied power, shock and vibration range of NEMA TS-2.

VSS-15 SNMP Managed UPS

A. The UPS will be a SNMP managed, 19” rack mountable, expandable unit.

B. The product will be scalable by adding additional rack mounted battery packs.

C. The System will provide 6-hours of uninterruptible power after a utility power outage.

D. The CONTRACTOR will the size the UPS system and submit for Norfolk Southern approval. The UPS system will fit within the equipment cabinet.

E. Be notified of problems to ensure crucial situations are dealt with in a timely manner. Scheduling capability to customize shut down and reboot of connected equipment. Data logging to identify problematic trends before they escalate or export the data log for analysis. Pinpoint the timing and sequence of events leading up to an incident with the event log. The device will provide information available to the Video Management System by forwarding SNMP traps (events)

F. Protocol Support to include:

1. HTTP, HTTPS, IPv4, IPv6, NTP, SMTP, SNMP v1, SNMP v3, SSH V1,SSH, SSL, TCP/IP, Telnet.

G. Network Interface: RJ-45 10/100 Base-T

H. 6-Hour runtime, sine wave output.

VSS-16 Payment and Measurement

A. Payment and measurement for CCTV and thermal installations shall be per each type of installation in accordance with the Plans. Payment shall include all camera(s), supporting equipment, wiring, communications connections, enclosures, labor, testing, and other material as shown on the Plans as required for a complete installation.

B. Payment and measurement for security camera central systems shall be as a lump sum. Payment shall include the security system server system, software, testing, communications connections, labor, and all other supporting materials and/or software as required for a complete installation.

C. Fiber optic cable shall be paid per section FOC – Fiber Optic Cable.

END OF SECTION

Division XI: Electrical Systems

Section LI – Site Lighting

Section EL – Electrical Power Distribution

Section LI – Site Lighting

LI-1 Description

Work shall include furnishing, installing, wiring, and testing new site lighting fixtures and pole in accordance with these specifications. Electrical power distribution and testing shall be covered under section EL – Electrical Power Distribution or its references.

LI-2 General Requirements

A. CONTRACTOR shall handle all materials with care to avoid damage. CONTRACTOR is responsible for all damage resulting from mishandling materials.

B. Each type of lamp and fixture shall be supplied new and by the same manufacturer.

C. All lamps and equipment shall be operational upon completion of the project.

D. Submittals:

1. CONTRACTOR shall provide submittals in accordance with the electrical specifications.

2. CONTRACTOR shall provide all submittals to the ENGINEER for approval prior to ordering materials, setting poles, or constructing foundations.

3. Fixture submittals shall include cut sheets, shop drawings, specifications, and product data for all light fixtures. Product data shall include dimensions, ratings, performance data, lamp and ballast data, weights, maintenance/operating instructions, and accessory information for each product.

4. High-mast light tower submittals shall include detailed cut sheets, shop drawings, specifications, and manufacturer's data for the high-mast tower, lowering system, fixtures, maintenance/operating instructions, and related components. CONTRACTOR shall also submit detailed wind loading and structural calculations and drawings for tower foundations to the ENGINEER for approval.

5. CONTRACTOR shall supply manufacturer testing documentation to show compliance with applicable NEC, IEEE, NEMA, UL, ANSI, NFPA, and local standards.

6. CONTRACTOR shall provide a computer-generated foot-candle layout for the entire facility with supporting calculations based on the fixtures being supplied.

E. General installation requirements:

1. Install all fixtures, light rings, poles, and other equipment in accordance with manufacturer's instructions.

2. Underground and exterior wire shall be type XHHW-2, USE or as shown on the Plans.

3. Bond each luminaire, each metal accessory, the ground rod, and the pole to the branch circuit equipment ground conductor with a separate ground wire sized per NEC or as shown on the Plans.

4. Operate each luminaire and light tower lowering mechanism after installation and connection. Inspect for improper connections and operations.

5. Aim and adjust luminaires as indicated on the Plans or as directed by the ENGINEER.

6. Clean all photometric control surfaces and all finishes. Touch-up any damaged finishes.

F. HID ballast general requirements:

1. Physical requirements:

a. Core and coil shall be vacuum impregnated with silica-filled polyester resin.

b. Core and coil shall use pre-insulated individual input voltage leads; floating lead and tab terminals are not acceptable.

c. Oil-filled capacitors shall be housed in corrosion-resistant steel or aluminum cans and contain ¼" quick disconnect terminals.

d. Dry capacitors shall be housed in a flame-retardant thermoplastic case with lead wire terminations and have no exposed live parts.

e. Igniters shall be polyester filled with either a plastic or aluminum external housing.

f. HID ballast kits with igniters shall have the igniters pre-wired to the core and coil, and have push-in connectors installed on the core and coil "cap" leads.

2. Ballasts shall be designed to provide reliable lamp starting down to –40°C for High Pressure Sodium, -30°C for probe-start Metal Halide, and –30°C/-40°C for pulse-start Metal Halide lamps (depending on lamp specifications).

3. Electrical performance:

a. Capacitors shall be 100°C dry type where rated voltage is 400, and contain bleeder resistors where required by UL. All oil filled capacitors shall contain an internal protective device.

b. Igniter shall be designed to operate an average of 10,000 hours at a case temperature of 75°C.

c. Igniter shall be 105°C rated.

4. Regulatory requirements:

a. Ballast shall be designed and manufactured in accordance with the ANSI Standard for HID Ballasts, ANSI C82.4.

b. Ballast shall be UL recognized in accordance with UL 1029 Standard for HID Ballasts or CSA certified in accordance with CAN/CSA-22.2 No. 74-92.

c. Manufacturer shall provide written warranty against defects in workmanship for two years.

d. Pulse start is required for all metal halide fixtures.

G. Fuses:

1. CONTRACTOR shall furnish and install a fuse holder in each ungrounded leg of the electrical circuit supplying the outdoor luminaire. The fuse and holder shall accessible though HML tower handholes.

2. Every luminaire shall be separately fused with a waterproof fuse holder.

3. Fuses shall be sized for the amperage of the luminaire.

4. Tap the circuit conductors with a minimum #10 AWG conductor to serve the luminaire.

H. Spares:

1. CONTRACTOR shall provide 10 percent of each lamp type of as spares, but not less than one of each type.

2. CONTRACTOR shall provide 5 percent of total fuses for each size as spares, but not less than one of each size.

LI-3 High Mast Light Poles

A. General:

1. CONTRACTOR shall furnish a high mast pole with a multiple section shaft, properly sized hand hole, anchor base, tenon and anchor bolts

2. The pole shall be capable of withstanding a sustained wind velocity of 100 mph with a 130% gust per 1994 AASHTO criteria while carrying all planned or anticipated equipment. At minimum, wind calculations shall include the pole, lowering device, luminaries, two security cameras (maximum future condition), and any antennas that would be installed on the tower according to the Plans.

3. The pole shall be supplied by the manufacturer of the lowering device and luminaires to ensure complete compatibility of all components.

4. The complete pole shall be galvanized in accordance with the requirements of ASTM A123. All welding shall be performed by AWS (American Welding Society) certified welders and all welds shall comply with most recent requirements of the AWS Structural Welding Code.

5. All poles and tower shall be installed plum. CONTRACTOR shall provide shims or double nuts to adjust plumb.

6. CONTRACTOR shall use belt slings or non-chafing ropes to raise and set pre-finished light towers.

7. Connect ground rods to ground conductors using an exothermic weld or non-reversible mechanical connection.

8. Bond each luminaire, each metal accessory, the ground rod, and the pole to the branch circuit equipment ground conductor with a separate ground wire sized per NEC or as shown on the Plans.

9. See section VSS – Video Security System for security/communications systems, cameras, equipment, and enclosures attached to the high-mast light towers.

B. Foundations:

1. Light tower foundations shall comply with section SC – Structural Concrete, COMM.53.28, and applicable local and State requirements.

2. Provide ground rods and attachment to light tower to comply with NEC grounding requirements.

3. All light tower foundations shall be cast-in-place. Pre-cast foundations are not permitted.

C. Pole shaft:

1. The pole shaft shall consist of multi-sided steel tubes with a standard taper rate of .14” per foot.

2. Poles consisting of multiple sections shall be field assembled and telescope together a minimum of 1.5 times the bottom section top diameter at the point of overlap.

3. No field welding shall be permitted in the assembly of the pole.

4. The steel material used for the pole sections shall meet the requirements of ASTM A572 or ASTM A595 Grade A as required for wind loading.

5. Material shall be single ply sheet, formed into a tubular shape with longitudinal welds. No circumferential welds are permitted.

6. The pole top tenon shall be 4.75" diameter by 8.50" height and integrally welded to the pole.

D. Base plate:

1. The base plate shall be integrally welded to the pole shaft with either a telescoping type joint with circumferential weld top and bottom or a full penetration butt weld with backup bar.

2. The base plate shall have an opening of adequate size to allow for insertion of the lowering system apparatus through the base plate.

3. The steel material used for the base plate shall meet the requirements of either ASTM A36 or ASTM A572 as required for wind loading.

E. Hand hole:

1. The hand hole shall be peripherally reinforced with flat steel bar integrally welded to the pole shaft.

2. The hand hole shall be minimum 10" wide by 30" high opening to allow for installing, maintaining and servicing the lowering device equipment. The hand hole shall begin at 15" from the top of the base plate.

3. Opposite the hand hole shall be a plate for mounting the lowering device winch assembly. The winch plate shall be minimum 13.5" width, 22.13" height with appropriate mounting holes pre-drilled. The winch plate shall be centered in the hand hole opening.

4. The hand hole shall be supplied with a gasketed, hinged cover, secured to the hand hole reinforcement with stainless steel fasteners. No internal reinforcement which could trap acid in a galvanizing process shall be permitted.

5. A ½"-13 nut shall be welded inside the pole adjacent to the hand hole opening for grounding purposes.

F. Anchor bolts:

1. Anchor bolts shall have a minimum threaded length of 10" or as shown on the Plans. The exposed threaded end shall be galvanized per ASTM A153.

2. Anchor bolts material shall be ASTM F1554 modified to minimum 55,000 psi or ASTM A615 minimum 75,000 psi.

3. Each anchor bolt shall be supplied with two hex nuts and two flat washers.

4. Anchor bolts may be designed with a hook or "L" on the embedded end or a threaded nut to help develop pullout resistance.

5. Project anchor bolts at least 2 inches above base.

6. Install all anchor bolts with anti-seize compound.

LI-4 High-Mast Tower Lowering Device

A. General:

1. Lowering device shall be supplied by the same manufacturer of the high-mast pole.

2. The lowering device, lighting fixtures and pole shall be manufactured and tested as an integral system and be provided and warranted by one manufacturer. The specifications shall consist of detailed line drawings, and the following written specifications. Any proposed deviation to be considered must include an analysis and certified test data demonstrating equal or greater performance.

3. The lowering device shall consist of three main sub-assemblies, including the headframe, lowering ring, and winch assembly.

4. All material shall be made of corrosion-resistant stainless steel, aluminum or galvanized steel unless otherwise specified.

5. All fixtures utilized on the lowering device shall have passed an accelerated vibration test of at least 1G.

6. The complete high mast system, consisting of lowering device and the specified luminaires shall be subjected to full-scale wind tunnel testing to determine actual loading for the high mast pole design.

7. See section VSS – Video Security System for security/communications systems, cameras, equipment, and enclosures attached to the high-mast light towers.

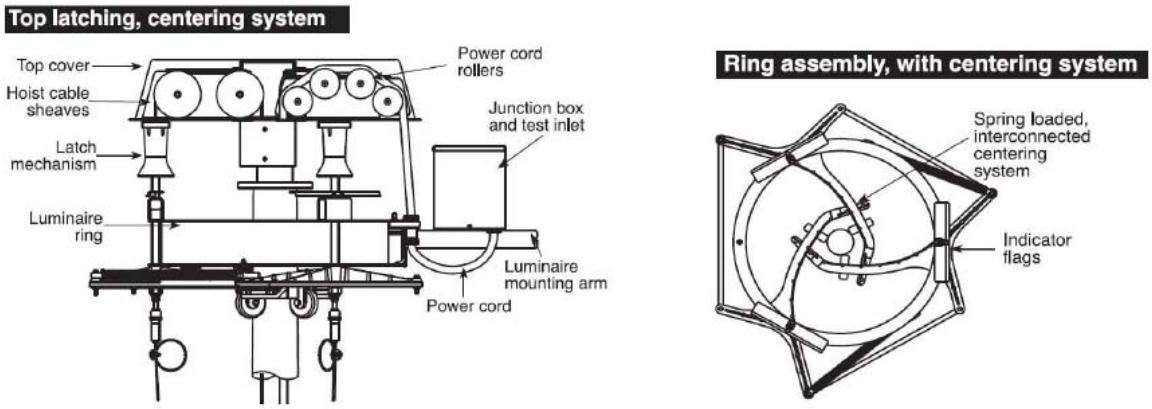

Figure 1: Typical High-Mast Lowering Device

B. Head frame assembly:

1. The head frame shall consist of a one piece welded assembly with a hot dip galvanized finish after fabrication.

2. All fasteners used for additional covers or other items shall be stainless steel.

3. The head frame shall incorporate a power cord roller assembly consisting of multiple rollers providing a minimum 7-inch bending radius for the cord. The design shall prevent the power cord from riding up the sides of the rollers and shall incorporate keeper bars on each end to secure the cord.

4. Cable sheaves:

   a. The head frame shall incorporate six hoist cable sheaves, each of which shall have a minimum six-inch diameter.

   b. Cable grooves shall be machined with a circular cross-section to match the cable diameter.

   c. Sheaves shall have oil impregnated, pressed in sintered bronze bushings.

   d. Each sheave shall be fabricated from steel and have a zinc electroplated finish per ASTM A633, including a yellow chromate dip.

   e. The sheaves shall meet or exceed the requirements of the Wire Rope Technical Board.

   f. Wire rope cables that operate over the sheaves shall be 7 x 19 construction aircraft cable, ¼" diameter stainless steel, and shall meet strength requirements of Federal Specification RR-W-410e.

5. Top latching:

a. Headframe assembly shall include three one-piece cast aluminum latch barrels.

b. Each latch barrel shall be designed to hold the entire weight of the ring, luminaires, and two optional cameras.

c. The latch barrels shall support the luminaire ring assembly in a latched position and unload the hoist cables, transition assembly, and winch when the device is not in operation.

d. The latch barrels shall incorporate internal cams to operate the latch pins. The cams shall not be exposed or subject to icing or other interference.

C. Ring assembly:

1. The light ring assembly shall be fabricated of #7 gauge steel with a hot dip galvanized finish.

2. The assembly shall include the appropriate number of luminaire mounting arm brackets fabricated from 2" pipe of sufficient strength to support the specified luminaire. Mounting arms shall be hot dip galvanized finished and shall bolt to the ring with stainless steel hardware.

3. The wiring enclosures shall constructed of formed aluminum with a lift off cover.

4. The entire assembly shall be weatherproof and be capable of a NEMA 3R rating. The enclosure shall include a weatherproof inlet for testing of the luminaires and lamps at ground level.

5. The enclosure shall be factory pre-wired with the appropriate number of 16/3 Type ST cords for luminaires and appropriately sized main power cord. The power cord shall be securely attached to the ring using cable clamps that grip the outer jacket of the cord.

6. The enclosure shall include a weatherproof inlet for testing of the luminaires and lamps at ground level.

7. The ring assembly shall include a NEMA 3R aluminum junction box for main power distribution on the ring. The junction box shall include a 600V terminal block and ground bar power distribution to the luminaires. The junction box shall also include properly sized terminal blocks and other equipment for distribution of camera power, video and control conductors. It shall also include a weatherproof inlet for testing of the camera, luminaires and lamps when the ring is in the lowered position for maintenance.

8. Ring assembly latch pins:

a. Three one piece, investment cast stainless steel latch pins shall be provided on the ring.

b. Each latch pin shall be capable of individually supporting the entire weight of the luminaire ring assembly.

c. Indicator flags shall distinguish the latching and unlatching sequence, which shall be visible from ground level.

d. The latching or unlatching sequence shall impart no more than one (1) G of force to any component of the system including luminaires and lamps.

D. Self-centering ring assembly:

1. The centering system shall consist of three roller contact, spring loaded, cast aluminum arms designed to protect the pole, luminaires and lamps from damage during raising and lowering of the luminaire ring assembly.

2. The centering system shall keep the ring concentric to the pole during the raising and lowering operation.

3. The centering arms shall be interconnected so all three arms operate simultaneously to prevent jamming of the system on the pole during high winds.

4. The springs shall be stainless steel.

5. The rollers shall be non-marking.

E. Transition assembly:

1. The transition assembly shall be designed to prevent misalignment of the three hoist cables.

2. The wire rope cables shall be attached to the transition assembly with properly sized wire rope thimbles and factory swaged fittings. The attachment shall prevent the wire rope cable from untwisting under load.

3. The transition plate shall be fabricated of steel with a zinc-plated finish including yellow chromate dip.

F. Winch:

1. The internal winch assembly shall have an ultimate strength of five times the lifted load.

2. The winch shall include a 30:1 worm gear reduction and an internal drag brake on the input shaft to prevent free spooling of the winch drum.

3. The winch drum shall be supported on both ends and internally mounted winches shall include a stainless steel cable keeper designed to aid the correct spooling of the winch cable. The winch drum shall be factory pre-wound with minimum ¼" diameter stainless steel high strength 7x19 construction aircraft cable.

4. The internal winch assembly shall include a receiver bracket designed to accept the portable drive motor assembly. Provision shall be made to enable the drive motor assembly to be locked or pinned to the bracket during operation.

G. Branch circuit protection:

1. The assembly shall include a circuit breaker sized for the correct voltage & phasing supplied for the luminaire load.

2. An aluminum or zinc plated steel cover shall be supplied for the circuit breaker.

3. A pigtail cord and plug shall be supplied from the circuit breaker assembly.

4. The cord and plug shall match the main power cord of the lowering device system.

H. Portable drive motor:

1. CONTRACTOR shall furnish one portable drive motor for the entire project obtained from the same manufacturer as the light tower, ring, and lowering device.

2. The drive motor assembly shall include a minimum 1 HP heavy duty reversing type electric motor with a stalled torque at least twice that required to operate the lowering device.

3. The motor shall drive the winch through a torque limiter coupling to limit the driving force on the hoist and winch cables. The torque limiter shall be factory pre-set.

4. The drive motor shall include a back-up shear pin designed to shear at a torque level between 50% and 100% above the torque limiter setting.

5. The drive motor assembly shall have a 20-foot cord with drum switch for remote operation.

6. The drive motor assembly shall be supplied with a step-down transformer to provide 120V to the motor.

I. Security camera provisions:

1. Each lowering device and ring shall be designed to support two optional CCTVcameras below the luminaire ring, and shall be balanced to allow lowering of the camera without causing degradation of the camera operations or damage any assembly component.

2. The CONTRACTOR is responsible for coordinating between the lighting and security camera providers for the successful installation of both systems.

3. The lighting supplier shall provide all camera mounts, handholes, and conduit on the light pole in coordination with security system requirements.

4. The lighting supplier shall provide all wiring for power and communications for the cameras between the camera and the base of the pole in coordination with security system requirements.

5. The camera shall be mounted to the luminaire ring such that its performance shall not be hindered by glare from the luminaires.

6. Camera power, video, and control conductors are to be installed and terminated from the junction box mounted on the self-centered ring assembly to the communications enclosure mounted on the foundation.

7. See section VSS – Video Security System for security/communications systems, cameras, equipment, and enclosures attached to the high-mast light towers.

LI-5 High-Mast Fixtures

A. General:

1. Fixture shall not exceed EPA of 1.34 square feet.

2. Fixture shall be UL listed for wet locations and UL listed for 40°C.

3. Fixture shall be manufactured and assembled in USA.

4. Luminaire dirt depreciation shall be less than 5% (LDD 0.95).

5. The electrical assembly shall be fully warranted for a period of 6 years from the date of manufacture.

6. The housing shall be fully warranted for a period of 2 years from the date of manufacture.

B. Mechanical construction:

1. The housing shall be die cast aluminum, include a seven stage pretreatment and finished with 2 to 4 mils of polyester powder paint.

2. The bracket arm clamp shall attach to a 51mm (2") nominal schedule 40 pipe and allow for ±3° adjustment for leveling the luminaire.

3. The fixture shall pass a vibration fatigue test per ANSI standards for Roadway Lighting Equipment - Luminaire Vibration.

C. Ballast:

1. The ballast shall be copper wound with power factor 90% or greater, and have a published ballast factor of 1.0 to ensure full output of the lamp.

2. The ballast shall reliably start the lamp in ambient temperatures to -20°F.

3. The ballast shall be low-loss with input watts not to exceed 446 Watts at 480V for 400W units and 1,065 Watts at 480V for 1,000W units .

4. All ballast components shall be completely removable as a unitized quick disconnect assembly for maintenance.

5. CONTRACTOR shall provide a terminal block to simplify wiring and provide positive electrical connections.

D. Optical and socket assembly:

1. The optical assembly shall consist of highly specular enhanced aluminum panels hermetically sealed between a spun aluminum cover and an open ventilated borosilicate glass piece.

2. The exposed smooth glass inner surface shall be continuously cleaned by the chimney effect of flow through air and subject to no permanent deterioration.

3. The lamp shall be operated in the vertical position for maximum life and lumen maintenance.

4. There shall be no glass bottom enclosure to scatter light above the horizon, to collect dirt or to reduce luminaire efficiency.

5. The luminaire shall provide an ANSI/IES Type V Full Cutoff distribution.

LI-6 Roadway Light Fixtures

A. General:

1. Fixture shall not exceed EPA of 2.05 square feet.

2. Fixture shall be UL listed for wet locations and UL listed for 40°C.

3. Fixture shall be manufactured and assembled in USA.

4. The fixture door shall contain all ballast components and be hinged for fast tool-free removal and replacement. Complete replacement shall take less than 60 seconds.

5. The electrical assembly shall be fully warranted for a period of 6 years from the date of manufacture. The housing shall be fully warranted for a period of 2 years from the date of manufacture.

6. See section VSS – Video Security System for security/communications systems, cameras, equipment, and enclosures attached to roadway light poles.

B. Mechanical construction:

1. The housing, door and fitter shall be die cast aluminum, and shall undergo a six stage cleaning and pretreatment process and over-coated with an electrostatically applied 2 to 4 mil coat of TGIC polyester powder paint cured at 425°F. The finish shall withstand a 160 inch-pound impact measured with a standard Gardner impact tester, and shall have passed a 1,000-hour salt spray test as specified by ASTM B-117. The finish shall exhibit no cracking or loss of adhesion from a 180° bend over a 1/8" mandrel diameter per ASTM D522.

2. All external hardware shall be corrosion resistant.

3. Housing access shall not require tools.

4. The fitter shall be built in and accommodate a standard 2 inch tenon or arm.

5. Electrical connection shall be inside the fitter assembly and not require fixture entry.

6. CONTRACTOR shall provide a terminal block inside the fitter.

C. Ballast:

1. The ballast shall be copper wound with power factor 90% or greater, and have a published ballast factor of 1.0 to ensure full output of the lamp.

2. The ballast shall reliably start the lamp in ambient temperatures to - 20°F.

3. The ballast shall be low-loss with input watts not to exceed 446 Watts at 480V.

4. The plug-in starter shall be totally encapsulated with a material that electrically and thermally insulates all components from lamp and ballast heat.

D. Optical and socket assembly:

1. The reflector shall consist of high purity (#3002 alloy) aluminum of minimum 0.08" thick sheet.

2. Flat lens shall be 1/8" fully tempered glass.

3. The reflector and lens optical assembly shall be designed to provide the IES pattern specified.

4. The socket shall be pulse rated, nickel-plated and lamp grip porcelain enclosed. It shall prevent undue lamp vibration and back-out.

E. Optional security CCTV and/or thermal cameras:

1. Coordinate with security camera supplier for mountings needed to secure the camera to the pole.

2. Camera power, video, and control conductors are to be installed and terminated from the camera to the communications enclosure mounted on the pole.

3. See section VSS – Video Security System for security/communications systems, cameras, equipment, and enclosures.

LI-7 Other Light Fixtures

A. General requirements for all fixtures:

1. All fixtures shall be watertight and UL listed for wet locations.

2. All fixtures shall have a maximum ambient operating temperature of at least 40°C, and minimum ambient operating temperature of -30°C

3. All fixtures shall be finished with a white thermal-setting polyester powder paint coating cured at 425°F. The finish shall withstand a 160 inch-pound impact measured with a standard Gardner impact tester, and shall have passed a 1,000-hour salt spray test as specified by ASTM B-117. The finish shall exhibit no cracking or loss of adhesion from a 180° bend over a 1/8" mandrel diameter per ASTM D522.

4. Fixture housings shall be constructed of die-cast aluminum with internal welds. Housings shall include watertight access door

B. T-Bar inspection lights:

1. CONTRACTOR shall furnish and install two inspection lights (one per lane) on each T-bar as shown on the Plans.

2. Inspection light shall consist of a mounting yoke assembly with pivoting luminaire and locking aiming nuts.

3. Lamp shall be 320 Watt pulse metal halide and configured for multivoltage applications (120V, 208V, 240V, and 277V) unless otherwise noted on Plans.

4. Assembly shall have an EPA of 2.6 square feet or less and maximum weight of 50 pounds.

C. Wall-mounted lights:

1. CONTRACTOR shall furnish and install one wall-mounted exterior light fixtures on each side of each camera portal (two per portal) and at any other locations as shown on the Plans.

2. Fixture shall be 250W metal halide and prewired for 120V unless otherwise shown on the Plans..

3. Fixture shall be designed for mounting directly to walls or other structures for surface wiring or over a recessed outlet box.

D. Ceiling-mounted light fixtures:

1. CONTRACTOR shall furnish and install one ceiling-mounted light fixture per gate lane on gate canopies and at any other locations as shown on the Plans.

2. Fixture shall consist of a square (24"x24" or less) ceiling-mounted light fixture designed for outdoor use and weighting less than 50 pounds.

3. Lamp shall be 400 Watt pulse metal halide and configured for multivoltage applications (120V, 208V, 240V, and 277V) unless otherwise noted on Plans.

4. Fixture shall have a flat, diffused tempered glass lens

E. Flourescent task lighting:

1. CONTRACTOR shall furnish and install four fluorescent task light fixtures per camera portal and at any other locations as shown on the Plans.

2. Fixture shall consist of a fluorescent light fixture intended for exterior use. The fixture shall be approximately 7 inches wide by four feet long with a watertight fiberglass or aluminum housing.

3. Fixture shall include a clear, UV-stabilized, and impact-resistant polycarbonate diffuser.

4. Fixture shall have at least two pre-punched stainless steel mounting brackets.

5. Fixture shall include two lamps and be configured for multivoltage applications (120V, 208V, 240V, and 277V) unless otherwise noted on Plans.

LI-8 Measurement and Payment

A. Measurement:

1. High-mast light tower poles shall be measured per each complete installation based on the pole length, excluding foundations or antennae.

2. Roadway lighting poles shall be measured per each complete installation based on installed pole length from ground level to the top of the pole.

3. Other light fixtures shall be measured per each type of fixture installed.

4. No separate measurement shall be made for fixtures installed as part of a canopy, camera portal, t-bar, or other structure.

B. Payment:

1. Payment for high-mast light towers shall be per each by pole height and number/type of fixtures. Payment shall include the pole, lowering device, complete fixtures, ancillary materials, labor, transportation, electrical connections and equipment, and other materials and labor required for a complete installation.

2. Payment for roadway light poles shall be per each by pole height and number/type of fixtures. Payment shall include the pole, complete fixture(s), ancillary materials, labor, transportation, electrical connections and equipment, and other materials and labor required for a complete installation.

3. Payment for other light fixtures shall be paid per each type of fixture installed. Payment shall include the fixture, mountings or bracket, labor, transportation, electrical connections, and other materials and labor required for a complete installation.

4. No separate payment shall be made for fixtures installed as part of a canopy, camera portal, t-bar or other structure. Payment for these structures shall include associated lighting as per this section.

5. No separate payment shall be made for supplying spare lamps and fuses.

6. No separate payment shall be made for supplying the portable HML tower lowering motor.

END OF SECTION

Section EL – Electrical Power Distribution

Refer to the current version of the
Norfolk Southern Electrical Specifications.

END OF SECTION