STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
GYRATORY CONTROLLED
QUALITY CONTROL/QUALITY ASSURANCE SPECIFICATIONS
FOR HOT MIXED ASPHALT CONCRETE PAVEMENT

DECEMBER 10, 2007

For all Gyratory Controlled Quality Control/Quality Assurance (QC/QA) Hot Mixed Asphalt Concrete Pavements irrespective of class, type, asphalt material, or pavement use, delete Section 320 from the Standard Specifications in its entirety and replace it with the following revised specification:

320.1 DESCRIPTION

These requirements are applicable to all Gyratory Controlled Quality Control/Quality Assurance (QC/QA) hot mixed asphalt concrete pavements irrespective of class, type, asphalt material, or pavement use. The work consists of constructing one or more courses of Gyratory Controlled QC/QA hot mixed asphalt concrete pavement on a prepared foundation.

320.2 MATERIALS

A. Composition of Mixtures: The asphalt concrete shall be composed of a mixture of aggregate, asphalt, and approved modifiers. Unless otherwise specified in the plans, no reclaimed asphalt pavements (RAP) are allowed in Gyratory Controlled QC/QA hot mixed asphalt concrete pavements. Aggregate fractions shall be combined in proportions that result in the asphalt mixture meeting the specified requirements.

The operation of the plant shall not commence until the Bituminous Engineer has verified, in writing, a job mix formula meeting the specification requirements (Tables A-K) for the asphalt concrete specified. The mixture shall conform within the range of tolerances established by the job mix formula target values shown in Table P.

B. Aggregates: Virgin mineral aggregate shall conform to the requirements specified in this provision. RAP, when required, shall conform to the requirements specified in the plans.

C. Asphalt Binder: Asphalt binder shall conform to Section 890.

D. Hydrated Lime: Hydrated lime shall conform to Section 760.

E. Burner Fuel: Burner fuel used for production of asphalt concrete shall be propane, butane, natural gas, Grade 1 fuel oil, Grade 2 fuel oil, Grade 4 fuel oil, Grade 4 (light)

fuel oil, Grade 5 (light or heavy) fuel oil, or Grade 6 fuel oil. Fuel oil heavier than Grade 2 shall meet the requirements of ASTM D396. Recycled fuel oils, RF04, RF05L, and RF05H may also be used provided they meet the requirements of ASTM D6448. The Contractor shall certify that each load of fuel meets the applicable ASTM specification.

F. Shoulder Joint Sealant: Joint sealant shall conform to Section 870.

320.3 CONSTRUCTION REQUIREMENTS

A. Weather and Seasonal Limitations: Asphalt concrete shall not be placed when the underlying surface is wet or frozen. Asphalt concrete shall not be placed when weather conditions prevent proper handling, compaction, or finishing. The temperature and seasonal limitations are as follows:

MINIMUM AIR TEMPERATURES & SEASONAL LIMITATIONS

Compacted Thickness	Surface Course		Subsurface Course & Shoulder Course	
	Min. Temp.	Seasonal Limits	Min. Temp.	Seasonal Limits
1” (25 mm) or less	45°F (7°C)	May 1 to Oct. 15 (inclusive)	45°F (7°C)	none
over 1” (25 mm)	40°F (4°C)	May 1 to Oct. 15 (inclusive)	40°F (4°C)	none

B. Equipment:

1. Requirements for All Plants: The central plant for mixing the mineral aggregate and asphalt may be a batch or drum mix type mixing plant.

Stockpiles of mineral aggregate shall be kept separate and adequate measures to prevent contamination must be used at stockpile sites. Segregated piles will be rejected until corrected.

When mineral filler, hydrated lime, or other additives are required, a separate feed system shall be provided to store and accurately and uniformly proportion the required quantity into the mix.

All cold feed bins shall be equipped with dividers to prevent overflow of aggregates into the adjacent bins.

The plant shall be equipped with emission control equipment including a dust collector capable of eliminating or conserving the dust necessary to meet gradation limits and environmental standards.

Recycled fuel oils and fuel oils heavier than Grade 2 used for burner fuel shall be properly preheated and efficiently burned. Production of mix shall be stopped if flameouts or signs of incomplete combustion occur.

A pyrometer or other thermometric instrument shall be installed in the supply line between the storage tank and the discharge point in the plant to accurately measure the temperature of the asphalt binder.

The plant shall be equipped with accurate weighing and volumetric measurement devices.

Asphalt binder storage tanks shall be kept level. Accurate calibration charts, which show the quantity of material contained in a tank at each 1/4 inch (5 mm) increment(s) of depth and a suitable device to measure the depth of the material, shall be provided. Storage tanks shall uniformly heat the material, under effective and positive control, to the required temperature. Heating shall be accomplished by steam coils, electricity, or burners, provided the flame does not come in direct contact with the heating tank. The asphalt circulating system shall be of adequate size to ensure proper circulation during the entire operating period. An accurate thermometer must be installed in the tank so temperature can be monitored.

Hydrated lime, when added, shall be added at the pugmill to moistened aggregate containing a minimum moisture content of 1.0 percent above the saturated surface dry condition of the aggregate, as noted on the approved mix design report. The mixing of the aggregate, hydrated lime and water shall be accomplished by using an enclosed twin-shaft pugmill with a minimum effective length of 4.5 ft (1.4 m). A water spray system must be installed at the discharge end of the pug mill. This water system must be used when directed by the Engineer to prevent fugitive lime dust from being released into the air.

When hydrated lime is used, the Contractors hydrated lime system shall be equipped with scales to accurately determine the amount of hydrated lime used at any time.

When RAP is required RAP, virgin aggregate, and asphalt binder shall be mixed by a conventional hot mix batch plant or a drum mix type hot plant.

2. **Batch Type Mixing Plants:** Batch type plants shall have at least two storage bins with sufficient capacity to furnish the quantity of mineral aggregate materials necessary to operate at the calibrated capacity of the plant. Each compartment shall have partitions that prevent diversion of material into other compartments. Vibrators shall be provided to prevent bridging or arching of the bin contents.

   Batch plants shall be fully automatic, to the extent that the only manual operation required would be for the proportioning of one batch utilizing a single actuation switch or starter.

   The automatic unit shall include a timer to automatically control the measuring, mixing, and dumping processes through a central control. The automatic unit shall include a time lock device, which is capable of controlling the operations of a complete mixing cycle.

When RAP is required, batch plants shall be modified to permit the cold salvaged asphalt mix material to feed directly into the weigh hopper of the plant.

When RAP is required, the heated virgin aggregate shall be deposited in the weigh hopper first followed by the cold salvaged mix material. These two materials shall be “dry” mixed for a minimum of 10 seconds before introduction of asphalt binder into the pugmill. Wet mixing time shall be a minimum of 25 seconds. Mixing times may be adjusted by the Engineer, as necessary, to achieve uniform mixing and coating. Discharge of the heated virgin aggregate shall be from one bin only and shall be discharged into the center of the weigh hopper. The amount of aggregate stored in the bin shall not exceed one batch in weight and shall be fed into the bin in a manner that will prevent segregation.

A recording pyrometer shall be mounted in the discharge chute of the dryer. Daily charts of continuous aggregate temperature readings shall be submitted to the Engineer.

In lieu of a recording pyrometer, a computer printout showing the aggregate temperature readings at the discharge chute of the dryer may be substituted as approved by the Engineer

3. **Drum Mix Plants:** The dryer drum shall uniformly heat, coat, and mix the materials without overheating the materials and adversely affecting the mixture.

   a. Materials and additives, except RAP, shall be fed simultaneously into the dryer.

   b. The virgin aggregate and RAP feed system shall provide positive control of the aggregate feed that can be easily and accurately calibrated. The rate of feed shall be continuously monitored by belt scale, or other device that is interlocked with the asphalt metering mechanism.

   c. RAP, when added shall be introduced into the drum and combined with the virgin aggregate so the RAP does not come into direct contact with the burner flame. Asphalt binder shall be added to the mixture in the drum after the aggregates have been combined.

   d. The asphalt metering device shall positively control the rate asphalt is introduced into the mixture and shall instantaneously adjust to variation in the aggregate feed rate.

   e. Production shall be limited to the rate required to obtain uniform aggregate coating and a uniform mixture meeting job mix temperature requirements. The rate must be within manufacturers rated plant capacity.

   f. A recording pyrometer shall be mounted in the discharge end of the mixer for determining the temperature of the mix. Daily mix temperature readings shall be submitted to the Engineer.

In lieu of a recording pyrometer, a computer printout showing the mix temperature readings at the discharge end of the mixer may be substituted as approved by the Engineer.

4. **Pavers:** Self-propelled pavers shall be equipped with a hopper having a bottom conveyor, a full width vibrating screed with heaters and be capable of spreading and finishing the mix to the specified widths, typical sections and thickness. The paver shall provide an accurate, smooth, uniform textured spread, and provide preliminary compaction.

   An attachment shall be provided on the paver that will place a beveled edge on the mat as specified.

   Pavers shall be equipped so that the height and transverse slope of the screed is automatically controlled using a fixed or traveling stringline on either or both sides of the paver. The traveling stringline shall utilize either mechanical skis or non-contacting grade averaging sensors. The traveling stringline shall have a minimum effective length of 28 feet (8.5 meters). The system shall be capable of manually controlling the transverse slope and the screed height.

5. **Rollers:** Rollers for compaction of the asphalt concrete shall be of the self-propelled type, capable of producing a smooth surface finish. The number and weight of rollers furnished shall be sufficient to compact the mix to the required density. The rollers shall be capable of being reversed smoothly, without shoving or tearing the asphalt concrete.

   Rollers shall be equipped to prevent "pickup" on the tires or drums. Moistening the drums or tires with water, a water detergent solution, or enclosing the roller to prevent heat loss from the tires may be required. The use of fuel oil or other petroleum solvents to prevent "pickup" will not be permitted. Measures shall be taken to prevent oil, grease, or fuels from being dropped on the mat by rollers or any other type of equipment.

C. Laboratories:

1. **Quality Control Laboratory:** The Contractor shall furnish and maintain a Quality Control (QC) laboratory at the plant site. The laboratory shall be furnished with the necessary space, equipment, and supplies to properly perform all specified testing. The laboratory shall be equipped with a gyratory compactor meeting the requirements of AASHTO PP 35. The laboratory equipment shall meet the requirements of the test methods contained in the Department’s Materials Manual and Materials Testing & Inspection Certification Program Manual. A copy of the equipment calibration records shall be kept in the QC laboratory.

   The Contractor's QC laboratory shall be equipped with a mechanical convection oven meeting the requirements of Section 600 of the Standard Specifications.

The Contractor shall furnish a cut off saw equipped with a diamond tipped blade. The saw is to separate the core samples to the actual lift thickness. The cores shall be sawed to the correct lift line prior to testing the cores for density.

2. **Quality Assurance Laboratory:** The Contractor shall also provide a separate Quality Assurance (QA) laboratory for QA testing performed by the Engineer. The QA laboratory shall meet the requirements of Section 600 of the Standard Specifications.

D. Quality Control:

1. **Contractor Furnished Quality Control Program:** QC for the asphalt concrete pavement is the responsibility of the Contractor. The Contractor shall provide and maintain a QC program. The program shall assure that all asphalt concrete materials and constructed pavement submitted for acceptance conforms to the contract requirements. The Contractor shall be responsible for all asphalt concrete materials and constructed pavement, including aggregate process control and handling.

   The Contractor shall provide at least one certified Level II and Level SP technician for conducting the QC testing and one certified level III technician for roadway inspection. All of the Contractors QC technicians shall meet the Departments certification requirements or be under the direct supervision of a certified technician for the type of work they are actually performing. The certified technicians must be present at the plant and roadway whenever the plant is supplying asphalt concrete to the roadway.

   At or prior to the preconstruction meeting the Contractor shall submit a QC plan to the Engineer for approval. The plan shall contain the following minimum requirements:

   a. The names and phone numbers of the individual(s) responsible for the Contractor's QC program.

   b. A listing of the certified technician(s) responsible for the QC inspection, material sampling, and testing.

   c. A copy of the completed Performance Checklist, Training and Evaluation Records for all Temporary or Seasonal personnel who will be performing QC inspection or sampling and testing.

   d. An organizational chart indicating lines of authority.

   e. The Contractor shall notify the Engineer if a Control Test Strip will be used. The Contractor may produce approximately 500 tons (500 metric tons) of material to establish a roller pattern and verify the field produced mix properties match those of the lab mix design. After test strip placement further mixing and laydown operations will be suspended until the laboratory test results of the asphalt mixture and core densities are available. The material used in the test strip will not be included in the mix pay factor analysis. The material used in the test strip

shall be tested for all the properties listed in Table M. The Engineer shall approve the location of the test strip.

If a Control Test Strip is not constructed, the QC plan shall specify how the contractor will establish a roller pattern to achieve the specified density and volumetrics.

The Engineer will provide the following to the Contractor at the preconstruction meeting:

Names of the certified individuals in charge of Quality Assurance (QA) testing and roadway inspection.

An organizational chart including the names and phone numbers of those in the direct line of authority.

2. **Mineral Aggregate Testing Prior to Production:** The aggregate producer shall provide test results to the Contractor and Engineer for each stockpile of virgin mineral aggregate that will be incorporated into the asphalt concrete mixture. The aggregate producer shall use a certified Level II and Level SP technician. The required tests shall include gradation, fractured faces, fine aggregate angularity, flat and elongated particles, sand equivalent, and lightweight particles at the following minimum frequencies:

   One test per 1500 tons (1500 metric tons) for each virgin mineral aggregate ingredient produced.

   A minimum of three tests for each virgin mineral aggregate stockpile.

   The Contractor may vary the frequency of the fractured faces, fine aggregate angularity, flat and elongated particles, sand equivalent, and lightweight particles tests on ledge rock sources depending on the quality and uniformity of the materials.

3. **Contractor Furnished Mix Designs:** Asphalt concrete mix designs shall be performed by the Contractor and verified by the Department's Bituminous Mix Design Lab. A certified Level IV and Level SP technician shall perform the asphalt concrete mix design. All Contractors submitting mix designs to the SDDOT are required to participate in the Proficiency Sample Program.

   Prior to submitting samples to the Department's Bituminous Mix Design Lab 50 percent of the plans quantity or 15,000 tons (15,000 metric tons), which ever is less, of the virgin mineral aggregate shall be produced.

   When RAP is required the Contractor shall sample the Rap material from the roadway by an approved method. This material shall be used to perform the mix design. A portion of this sample shall be submitted to the Department's Bituminous Mix Design Lab. The Contractor shall notify the Area Engineer prior to sampling materials from the roadway.

Samples for aggregate quality testing shall be submitted to the Department's Bituminous Mix Design Lab a minimum of fifteen working days prior to hot mix production. Mix designs will only be performed on samples when accompanied by the following information:

a. A completed data sheet (form DOT 1), including the legal description of virgin mineral aggregate source(s).

b. Representative virgin mineral aggregate samples and RAP samples shall be proportionate to the bin splits proposed for use during construction. The total aggregate submitted for mix design verification shall be from 400 to 500 pounds (180 to 230 kilograms).

The samples shall be obtained by the Contractor and delivered to the Department's Bituminous Mix Design Lab in Pierre, SD. The Contractor shall notify the Area office prior to sampling and submitting the mix design aggregate. A representative from the Area office shall witness all sampling of aggregates to be submitted for mix design.

c. A summary sheet showing all test results from the gradations completed and the average gradation of each mineral aggregate stockpile produced along with the proposed bin splits to be used in the production of asphalt concrete pavement.

d. A two-gallon (eight liter) sample of asphalt binder intended for use shall be obtained from the designated supplier for the project.

e. A temperature viscosity chart or the kinematic viscosity at 300 and 150 centistokes. A recommendation from the asphalt binder supplier on the lab and field mixing and compaction temperatures shall be included for all asphalt binders.

f. The specific gravity of the asphalt binder intended for use.

g. A mix design report and form DOT 48 that includes the lab data and results required in SD 316, AASHTO R 35, and AASHTO T 312. The Contractor's mix design shall meet all of the mix design specifications.

When the mix design verification is completed by the Department's Bituminous Mix Design Lab, an approved mix design report (DOT 64) will be provided to the Area Engineer and the Contractor prior to production. The mix design report will include the single percentage of aggregate passing each required sieve size, a single percentage of asphalt binder to be added to the aggregate, a single percentage of hydrated lime to be added to the aggregate, a single asphalt binder application temperature, a single temperature at which the mix is to be discharged from the mixer, and a single temperature at which the mix is to be delivered on the road.

4. Gyratory Controlled QC/QA Mix Design Requirements and Specifications: Unless otherwise specified in the plans, the mix design criteria shall conform to the following requirements.

a. Consensus Virgin Mineral Aggregate Requirements:

1.) Fractured Faces (Crushed Particles; SD 211)
The Fractured Faces shall be tested on the composite virgin mineral aggregate sample.

Table A Fractured Faces	
	Two or more fractured faces (%)
Class Q1	50
Class Q2	65
Class Q3	75
Class Q4	90
Class Q5	100

2.) Fine Aggregate Angularity (AASHTO T 304 Method A)

Table B - Fine Aggregate Angularity	
	Minimum Uncompacted Void Content (%)
Class Q1	40.0
Class Q2	41.0
Class Q3	43.0
Class Q4	44.0
Class Q5	45.0

3.) Flat and Elongated Particles (ASTM D 4791)
The maximum amount of flat and elongated particles for the coarse aggregate shall not exceed the limits shown in Table C. Flat and elongated particles are defined where the ratio of maximum to minimum dimension is greater than five to one. The aggregate tested shall be the composite virgin aggregate material that is retained on a 4.75 mm (#4) sieve

Table C – Flat and Elongated Particles	
	Maximum Flat and Elongated Particles (%)
Class Q1	No Limit
Class Q2	10.0
Class Q3	10.0
Class Q4	5.0
Class Q5	5.0

4.) Sand Equivalent (AASHTO T 176; Alternate Method No. 2, Pre-Wet) Obtain the sample by the pre-wet method and then dry the sample before conducting the sand equivalent test.

Table D - Sand Equivalent	
	Sand Equivalent Minimum (%)
Class Q1	40
Class Q2	42
Class Q3	45
Class Q4	50
Class Q5	60

b. Source Virgin Mineral Aggregate Requirements:

1.) Source Virgin Mineral Aggregate Requirements

Table E - Source Mineral Aggregate Requirements					
	Light Weight Particles (SD 208 & SD 214)		Sodium Sulfate Soundness (SD 220; 5 cycles)		Los Angeles Abrasion Loss (AASHTO T96)
	+4.75mm (#4)	-4.75mm (#4)	+4.75mm (#4)	-4.75mm (#4)	
Class Q1	4.5% maximum	4.5% maximum	15% maximum	15% maximum	45 % maximum
Class Q2	3.0% maximum	3.0% maximum	15% maximum	15% maximum	45 % maximum
Class Q3	3.0% maximum	3.0% maximum	15% maximum	15% maximum	40 % maximum
Class Q4	1.0% maximum	1.0% maximum	12% maximum	12% maximum	35 % maximum
Class Q5	0.5% maximum	0.5% maximum	12% maximum	12% maximum	35 % maximum

2.) Gyratory Controlled QC/QA Gradation (Sieve Analysis; SD 202)
Gyratory Controlled QC/QA gradations must be within the control points for the designated nominal aggregate size.

Table F - Gyratory Controlled QC/QA Gradation[(1)]		
	Control Points (percent passing)	
Sieve - in (mm)	Min.	Max.
3/4 (19)	100	
1/2 (12.5)	90	100
3/8 (9.5)		90
#8 (2.36)	28	58
#200 (0.075)	2.0	10.0

(1) The gradation sample shall not include hydrated lime.

c. Mixture Requirements:

1.) Gyratory Compactive Effort

The mixture shall be compacted in accordance with AASHTO T 312. The number of gyrations and densification criteria are in listed in Tables G and H.

Table G - Gyratory Compactive Effort			
	$N_{initial}$	N_{design}	$N_{maximum}$
Class Q1	6	50	75
Class Q2	6	65	100
Class Q3	6	65	100
Class Q4	7	75	115
Class Q5	7	85	130

2.) Mixture Densification Criteria

Table H – Mixture Densification Criteria			
	Percent of Mixture Maximum Specific Gravity (G_{mm})		
	$N_{initial}$	N_{design}	$N_{maximum}$
Class Q1	≤91.5	96.0	≤98.0
Class Q2	≤91.0	96.0	≤98.0
Class Q3	≤90.5	96.0	≤98.0
Class Q4	≤90.0	96.0	≤98.0
Class Q5	≤89.0	96.0	≤98.0

3.) Voids in Mineral Aggregate Criteria (VMA)

VMA is calculated from the mixture bulk specific gravity at N_{design} gyrations.

Table I - Voids in Mineral Aggregate Criteria	
Nominal Maximum Aggregate Size	Minimum VMA, Percent(1)
Class Q1	14.0
Class Q2	14.0
Class Q3	14.0
Class Q4	14.0
Class Q5	14.0

(1) The minimum VMA percent required for Hot Mix during production shall be 13.5

4.) Voids Filled with Asphalt (VFA)

VFA is calculated from the mixture bulk specific gravity at N_{design} gyrations.

Table J - Voids Filled with Asphalt Criteria	
	VFA, percent
Class Q1	70-80
Class Q2	65-78
Class Q3	65-78
Class Q4	65-75
Class Q5	65-75

5.) Dust to Binder Ratio

The dust to binder ratio shall be 0.6 to 1.4 The dust to binder ratio is calculated as the percent by mass of the material passing the #200 (0.075mm) sieve (including hydrated lime) divided by the effective asphalt binder content (expressed as percent by mass of mix). If the aggregate gradation percent passing the #8 (2.36 mm) sieve is less than 39 percent at mix design, the dust to binder ratio shall be increased to 0.8 to 1.6.

6.) Moisture Sensitivity (SD 309)

The minimum retained tensile strength ratio for the mixture is 80 percent. The moisture sensitivity requirement will be waived if 1.0% hydrated lime is added to the mix. Hydrated lime will not be required, or can be added at a rate lower than 1.0% if the moisture sensitivity requirement is met. If lime is used, a minimum of 0.5% hydrated lime shall be added to the mix. Liquid anti-stripping additives will not be allowed in lieu of hydrated lime. An item will be included in the contract for hydrated lime. Payment for hydrated lime will only be made when hydrated lime is actually used. Moisture Sensitivity will only be evaluated during the mix design process.

7.) Asphalt Pavement Analyzer: (AASHTO TP 63-03)

Table K - Asphalt Pavement Analyzer Criteria	
	APA, Maximum Rutting (mm)
Class Q1	8
Class Q2	7
Class Q3	6
Class Q4	5
Class Q5	5

8.) Moisture Content of Mix

The maximum moisture in the field produced mix shall be 0.3 %. The mix shall be sampled from the laydown machine and placed in an airtight tared container. The mix shall be dried to a constant mass as described in SD 305.

5. Quality Control Testing:

a. Calibration Testing:

1.) **Cold Feed:** Prior to production of asphalt concrete, the QC and QA certified technicians shall conduct comparison tests at the plant with a split companion cold feed calibration sample of virgin aggregate to assure that all associated equipment and procedures provide comparable results. Comparison test results shall meet the requirements of the mix design report and shall conform to the tolerances shown in Table L. The split companion calibration testing shall continue until the results meet the requirements of the mix design report and are within the listed tolerances. The split companion calibration testing shall be performed on each mix type produced prior to production of that mix type.

2.) **Mixture Testing:** The QC and the QA technicians shall perform correlation testing on a reheated prebuilt split companion sample (from the mix design process) supplied by the Contractor. The correlation testing will be for the theoretical maximum specific gravity (Rice Method) and gyratory bulk specific gravities.

Two gyratory compaction samples shall be made using a compactive effort of N_{design} and one gyratory sample made using a compactive effort of $N_{maximum}$ when required. The bulk specific gravity shall than be measured on specimens compacted to N_{design} and $N_{maximum}$ gyrations. The bulk specific gravity at the compactive effort of $N_{initial}$ shall be calculated by multiplying the bulk specific gravity at N_{design} by the ratio of the heights of the specimen at N_{design} divided by $N_{initial}$. Air voids shall be calculated using the theoretical maximum specific gravity and bulk specific gravity at N_{design} gyrations. The percent of theoretical maximum specific gravity densification shall be determined at $N_{initial}$, N_{design} and $N_{maximum}$. The results shall be within the tolerances shown in Table L.

3.) **Bulk Specific Gravity Reheat Correlation:** The QC and the QA technicians shall perform a reheat correlation test for the bulk specific gravity. The reheat correlation test shall be performed on a split sample of a sublot from within the first lot of production for the mix design. An additional reheat correlation test shall be performed on a split sample of a sublot from within the first lot of production for any new mix designs.

Cool a split portion of the sample down to room temperature. After the split sample has cooled, reheat and compact according to AASHTO T 312. Calculate the difference in the bulk specific gravities of the non-reheated and reheated tests. The average difference using the QC and QA technician's test results will be the correction factor for a reheated bulk specific gravity. This test may be repeated at the discretion of the Contractor or the Engineer.

Table L – TOLERANCE BETWEEN QC, QA, AND IA TEST RESULTS		
	Attribute	Tolerance
a.	Sieve 9.5 mm (3/8 in) & larger	± 5 %
b.	Sieve 4.75 mm (#4) thru 300 μm (#50)	± 3 %
c.	Sieve 150μm (#100) thru 75 μm (#200)	± 1.5 %
d.	Lightweight Particles	± 1.0 %
e.	Sand Equivalent	± 5 %
f.	Fractured Faces	± 10 %
g.	Fine Aggregate Angularity	± 1 %
h.	Flat and Elongated Particles	± 2 %
i.	Air Voids	± 1.2 %
j.	Bulk Specific Gravity of Asphalt Concrete (gyratory) @ $N_{initial}$, N_{design} and $N_{maximum}$ ($N_{initial}$ calculated)	± 0.020
k.	Mixture Densification @ $N_{initial}$, N_{design} and $N_{maximum}$	± 1.0%
l.	Maximum Specific Gravity (Rice)	± 0.020

b. Asphalt Concrete Quality Control (Production) Testing: After the calibration cold feed and mixture testing is completed and the results are within the specified tolerances, the Contractor will be allowed to begin production of asphalt concrete.

The Engineer shall randomly determine all sample locations at a frequency meeting the requirements of Table M. Sampling and splitting not performed by the Engineer shall be witnessed by the Engineer. To ensure that a representative random sample is obtained, the QC sample locations shall only be given to the Contractor immediately prior to sampling. The hot mix sample shall be obtained before the cold feed gradation sample. If lime is used in the mix, the lime shall be momentarily shut off while obtaining the cold feed gradation sample. If lime is to be included in the mix, care shall be taken to ensure that the hot mix sample is obtained with lime included in the sample. There will be a 200 ton (200 metric ton) buffer between the random sample locations. The intent of the buffer is to prevent back-to-back sampling and to more evenly distribute the sampling and testing workload.

A lot shall consist of five sublots. Sublots shall not represent more than 1000 tons (1000 metric tons) of asphalt concrete unless the current sublot is terminated.

The Contractor shall obtain QC samples at the specified locations for four of the five sublots. The Engineer will sample and split a minimum of one of the five sublots, and witness all QC sampling. The Contractor shall test all five sublot samples (a split of the one sublot sampled by the Engineer and four sublot samples taken by the Contractor). The material shall be sampled, split and tested by the methods and procedures described in the Department's Materials Manual.

The aggregate and hot mix samples shall be large enough to obtain four (4) splits of the minimum sample size needed for testing. If the sample is to be used for IA testing, the samples shall be large enough to obtain six (6) splits of the minimum size needed for testing. Immediately after splitting, the QA technician shall take possession of half of the sample for all of the QC samples. The QA technician shall ensure the Department's portion of the backup samples for all QC and QA tests are properly labeled, stored and retained until the end of the project. The QC technician shall retain their backup split until the QC, QA and IA technicians have obtained their test results for the individual lot and have found the results to be within the allowable tolerances in Table L, SD 317, and the Engineer has approved the disposal of the backup samples.

Table M - Minimum Frequency For Production Sampling/Testing

TEST		MINIMUM FREQUENCY	TEST METHOD
Virgin Mineral Aggregate Gradation*		1/1000 ton (M ton)	SD 202
Lightweight Particles*		1/1000 ton (M ton)	SD 208 & SD 214
Sand Equivalent*		1/1000 ton (M ton)	AASHTO T 176
Fractured Faces*		1/1000 ton (M ton)	SD 211
Fine Aggregate Angularity*		1/1000 ton (M ton)	AASHTO T 304
Flat and Elongated Particles*		1/1000 ton (M ton)	ASTM D 4791
Max. Specific Gravity of Asphalt Concrete (Rice Method)**		1/1000 ton (M ton)	SD 312
Bulk Specific Gravity of Asphalt Concrete (gyratory)**	$N_{initial}$	1/1000 ton (M ton)	calculation
	N_{design}		AASHTO T 312 (average of 2 specimens)
	$N_{maximum}$	1/5000 ton (M ton)	AASHTO T 312 (one specimen)
Mixture Densification	$N_{initial}$	1/1000 ton (M ton)	Calculation (AASHTO T 312)
	N_{design}		
	$N_{maximum}$	1/5000 ton (M ton)	
Voids in Mineral Aggregate (VMA) @ N_{design}		1/1000 ton (M ton)	Calculation (AASHTO PP 28)
Voids Filled with Asphalt (VFA) @ N_{design}		1/1000 ton (M ton)	Calculation (AASHTO PP 28)
Dust to Binder Ratio		1/1000 ton (M ton)	Calculation (AASHTO PP 28)
Asphalt Binder Content (sticking the tank)		1 per day	SD 314
Hydrated Lime Content		1 per day	
Moisture Content of Mix**		1/10000 ton (M ton)	SD 305
Density, In Place***		2/1000 ton (M ton)	SD 315

* Samples shall be taken according to SD 201 Section 3.2.

** Samples shall be taken from either the windrow in front of the laydown machine or from behind the laydown machine. The Contractor shall have the

option of where the samples are to be taken. The Contractor shall designate his choice of sampling locations at the preconstruction meeting.

*** Two density cores per 1000 ton (M ton) sublot shall be taken for determination of in place density. The average of the two core density results will be the 1000 ton (M ton) sublot value used for density in the pay factor calculations. The Engineer will determine and mark the core locations after the mix is placed and compacted. The cores will be taken the next working day after the asphalt pavement is placed. The Contractor shall perform the coring under observation by the Engineer. The Engineer will take immediate possession of the core samples for density testing. The Contractor shall fill all core holes before the end of the next working day with hot asphalt concrete and compact the mix to a density close to that of the surrounding pavement.

Core samples for density will be tested by the Engineer.

The Contractor may request to reduce the QC testing frequency when the QC samples and the QA samples indicate acceptable results, within the specifications in Tables A-E and the tolerances from Table L, for fractured faces, fine aggregate angularity, flat and elongated particles, sand equivalent, and lightweight particles, and the Engineer and the Contractor are both confident that future production will meet specifications The reduction in test frequency shall be authorized in writing by the Area Engineer.

The frequency of the QC testing for sand equivalent, lightweight particles, and fractured faces may be further reduced by the Area Engineer. The Area Engineer may reduce the frequency beyond what is shown the in QC Test Frequency Reduction Guidelines based on an evaluation of test results from the material source. The Area Engineer shall notify the Contractor in writing of the reduction in testing frequency and a copy of this letter shall be forwarded to the Region Materials Engineer and Certification Engineer. A reduction in testing frequency may be revoked by the Area Engineer at any time. The QA technician shall complete all of the required tests on the samples that are selected for QA testing.

The frequency of tests performed may be reduced using the following procedure. The QC technician shall complete all tests on the first lot of material produced. A reduction in the frequency of testing shall be allowed based upon the average test results obtained from the first lot of material tested by the QC technician. This reduction in test frequency for any of the test shown in the QC Test Frequency Reduction Guidelines shall remain in effect as long as the test results remain within the range of the testing frequency currently being used.

The QA technician will complete all of the required tests on the samples that are selected for QA testing.

QC TEST FREQUENCY REDUCTION GUIDELINES

Sand Equivalent

10 or more above minimum	Reduce test frequency to 1 test per lot
7 to 9 above minimum	Reduce test frequency to 2 tests per lot
4 to 6 above minimum	Reduce test frequency to 3 tests per lot
Within 3 of minimum	No reduction in test frequency

+ #4 and - #4 Lightweight Particles (less than 1.95 Specific Gravity)

1.5 % or more below maximum or results of 0.0 % Lightweight Particles	Reduce test frequency to 1 test per lot
1.1 to 1.4 % below maximum	Reduce test frequency to 2 tests per lot
0.6 to 1.0 % below maximum	Reduce test frequency to 3 tests per lot
Within 0.5 % of maximum	No reduction in test frequency

Fractured Faces

25 % or more above minimum or results of 100% Fractured Faces	Reduce test frequency to 1 test per lot
16 to 24 % above minimum	Reduce test frequency to 2 tests per lot
6 to 15 % above minimum	Reduce test frequency to 3 tests per lot
Within 5 % of minimum	No reduction in test frequency

Flat and Elongated Particles

7 % or more below maximum or results of 0 % Flat and Elongated Particles	Reduce test frequency to 1 test per lot
5 to 6 % below maximum	Reduce test frequency to 2 tests per lot
3 to 4 % below maximum	Reduce test frequency to 3 tests per lot
Within 2 % of maximum	No reduction in test frequency

Fine Aggregate Angularity

2.5 % or more above minimum	Reduce test frequency to 1 test per lot
2.0 to 2.4 % above minimum	Reduce test frequency to 2 tests per lot
1.5 to 1.9 % above minimum	Reduce test frequency to 3 tests per lot
Within 1.4 % of minimum	No reduction in test frequency

c. Specification Control Limits: The control limits of materials being produced will be evaluated under two different categories, Pay Factor Attributes and Non-Pay Factor Attributes.

1.) Pay Factor Attributes: Air voids and in place density (compaction) are the two pay factor attributes. These attributes will be statistically analyzed for contract unit price adjustment.

The percent air voids shall meet the requirement in Table N and the in place density of the asphalt concrete when expressed as a percent of the lot average maximum specific gravity (Rice Method) shall meet the requirements in Table N.

TABLE N - PAY FACTOR ATTRIBUTES			
a.	% Air Voids	4.0% ± 1.0%	
b.	In Place Density (% Compaction)	Class Q1	91.0% to 96.0%
		Class Q2	91.0% to 96.0%
		Class Q3	92.0% to 96.0%
		Class Q4	92.0% to 96.0%
		Class Q5	92.0% to 96.0%

When field test results for air voids or in place density deviate from the job mix formula values, the Contractor may adjust the gradation and/or asphalt binder content within the allowable tolerances shown for items a, b, c, and d shown in Table P. Bin splits may be adjusted up to ± 5 percent from the job mix formula bin splits. Adjustments shall be made as a result of an interactive process between the Contractor and the Engineer. The Contractor's recommendations shall prevail, provided all specifications and established mix design criteria are being met.

If new materials need to be incorporated into the asphalt concrete, a new mix design will be required by the Contractor (unless otherwise approved by the Bituminous Engineer) with verification by the Department’s Bituminous Mix Design Lab. The Contractor shall be responsible to verify that all mix design criteria are being met prior to written job mix formula approval.

When a new job mix formula is required, the current sublot shall be terminated and incorporated into the previous sublot for pay factor analysis. A new lot will be started when production is changed to the new job mix formula. At the end of production, the current sublot shall be terminated and incorporated into the previous sublot.

2.) Non-Pay Factor Attributes: There are several requirements not used in the determination of the pay factor that are very important to the performance of the asphalt concrete. The below listed attributes are tested at the frequency listed in Table M. The attributes shall be maintained within the requirements in section 320.3 D.4 or as otherwise specified.

Table O – Non-Pay Factor Attributes
Virgin Mineral Aggregate Gradation
Asphalt Binder Content
Hydrated Lime Content
Moisture Content of Mix
Sand Equivalent
Lightweight Particles
Fractured Faces
Fine Aggregate Angularity
Flat and Elongated Particles
Voids in Mineral Aggregate (VMA)
Voids Filled with Asphalt (VFA)
Dust to Binder Ratio
Densification @ $N_{initial}$ & $N_{maximum}$

The Asphalt Binder and Hydrated Lime content are not statistically evaluated as pay factor attributes, but may be price adjusted (DOT-18) for failure to conform to specification requirements.

If three out of any five consecutive tests for the Densification at $N_{initial}$ exceed the criteria in Table H, the Contractor shall immediately cease operations. A new mix design will be required by the Contractor (unless otherwise approved by the Bituminous Engineer) with verification by the Department's Bituminous Mix Design Lab prior to resuming production. The Contractor shall be responsible to verify that all mix design criteria are being met.

The VMA and Dust to Binder Ratio are calculated using the asphalt binder percentage determined from the daily cutoff from that day's production. The bulk specific gravity of the mineral aggregate will be determined by the SDDOT central lab during the mix design verification.

The bulk specific gravity of the mineral aggregate may be tested during production at the discretion of the Contractor or the Engineer. A split portion of material shall be given to the other entity for verification.

If the VMA, or Dust to Binder ratio values fails to meet the requirements in section 320.3 D.4, the Contractor shall stop production until corrective measures are taken.

TABLE P - JOB MIX FORMULA TOLERANCES

	Attribute	Tolerance from Target Value
a.	Sieve 5/8" (16 mm) thru 3/8" (9.5 mm)	± 7 %
b.	Sieve #4 (4.75 mm) thru #50 (300 μm)	± 5 %
c.	Sieve #100 (150 μm) thru #200 (75 μm)	± 2.0 %
d.	Percent Asphalt Binder	± 0.3 %
e.	Sand Equivalent*	Minimum or more
f.	Percent Lightweight Particles*	Maximum or less
g.	Fine Aggregate Angularity*	Minimum or more
h.	Fractured Faces*	Minimum or more
i.	Percent Flat and Elongated Particles*	Maximum or less
j.	Percent Hydrated Lime	± 0.10 %
k.	Asphalt Application Temperature	± 20°F (±11°C)
l.	Temp. of Mixture when emptied from the mixer	± 20°F (±11°C)
m.	Temp. of Mixture on delivery to the road	-20°F & +30°F (-11°C & +17°C)

*These properties are not listed on the job mix formula but will be tested for compliance with the mix design specifications listed in Tables A-E.

If two out of any five consecutive tests for the gradation requirements (Items a, b, or c) fail to meet the tolerances contained in Table P, the Contractor shall immediately cease operations. The Contractor shall investigate the cause of the variation in production. Production will not be allowed to resume until a passing cold feed sample is obtained and the Engineer has approved the corrective action.

If the asphalt binder content or hydrated lime content falls outside the tolerance in Table P, the Contractor shall stop production until corrective measures are taken.

If the sand equivalent, percent lightweight particles, fine aggregate angularity, fractured faces, or flat and elongated particles (Items e, f, g, h, or i) for a single test fall outside the tolerances shown in Table P, the Contractor shall immediately cease operations. The Contractor shall investigate the cause of the variation in production. The Contractor will not be allowed to continue operations until a passing cold feed sample is obtained and the Engineer has approved the corrective action.

The maximum moisture content in the field-produced mix shall be 0.3 %. If the moisture content in the mix exceeds the maximum allowed the Contractor will be required to take corrective action that is documented by the Engineer. Burner adjustments, increase mix temperature, slower plant production rates, use of drier aggregates, or adjust the amount of time material is in drum for mixing and heating are possible corrective actions. Additional moisture content in the field-produced mix tests shall be conducted to verify that the corrective action has worked to produce specification mix.

3.) **Test Identification:** Number the production control sublot tests consecutively in accordance with the Department's Materials Manual starting with number "QC01" or "QC001" based on the total number of samples needed. The two density cores in a sublot shall have the same number along with an "A" or "B" designation and shall match the sublot number. Use "N" before the sublot number for non-pay factor material. Use "Info" before the number for information samples. Use "R" after the number for remedial samples. Use "Cal" before the number for calibration samples.

4.) **Control Charts:** The Contractor shall provide QC charts that include the control limits and each individual test result for the following parameters:

a) Gradation of the control sieves in the Job Mix Formula
b) Asphalt Binder Content
c) Hydrated Lime Content
d) Maximum Specific Gravity (Rice)
e) Bulk Specific Gravity (Gyratory)
f) Air voids
g) In-place density
h) VMA
i) VFA
j) Dust to Binder Ratio

QC test results shall be recorded on the control charts immediately after completion of the test. The control charts shall also include the QA and Independent Assurance test results. The control charts shall be prominently displayed and accessible to the Engineer. The control charts shall be given to the Engineer upon completion of the project.

5.) **Documentation:** The Contractor is responsible for documenting all observations, inspection records, mixture adjustments, and test results on a daily basis. The Contractor shall also record and maintain a plant record of plant starts and stops, mix temperatures leaving the plant, bin split of aggregates, and the temperature of the asphalt binder going into the mix.

Field observations and inspections shall be noted as they occur in a permanent duplicating field book or diary, provided by the Engineer. The roadway diaries shall include hours paved, equipment in use, stations paved, course depth, width, crown, spread checks, tonnage, weather, and temperature of mixture delivered to the road. Plant diaries shall include plant start and shutdown times, mix temperature of material produced, binder spot checks, aggregate bin splits being used, actual calculated asphalt binder percentage for the day, tons of mix produced, mixture or aggregate adjustments, and weather conditions.

The Engineer will collect copies of documentation records and recorded mix temperature charts daily. All records shall be made available at all times upon request by the Engineer. The test results and original work sheets for the

production control testing listed in Table M shall be given to the Engineer upon completion of the test.

E. Quality Assurance: The Engineer will randomly sample and test a minimum of one sublot for each lot. The Engineer may test any or all of the splits of the QC sublot samples as part of the QA program.

The services of contractor's personnel to assist in obtaining the QA samples should be limited only to instances when hazardous conditions or liability issues exists that dictate their involvement and the following requirements are meet:

1. The QA sample location or time is only given to the contractor immediately prior to sampling.
2. The contractor's personnel are used only to provide labor to assist in physically obtaining the QA sample.
3. The Engineer is present to witness the taking of the QA sample.
4. The Engineer witnessing the sampling and the contractor labor performing the sampling are certified in accordance with the Department's Certification program.
5. The Engineer immediately takes possession of the QA sample.

QA test results will be made available to the Contractor within 24 hours, or the next working day.

The split sample test results (QA) of the sample taken by the Engineer will be compared to the Contractor test results (QC) for conformance with Table L. Populations of the QC sample test results will be compared to the QA sample test results utilizing the procedures shown in SD 317. If the test results are within the allowable tolerances, found to be similar, and found to represent the same population, as determined by F-test and t-test statistical evaluation procedures, the Contract unit price adjustments will be based on the Contractor QC test results.

Sampling and splitting not required to be performed by the Engineer will be witnessed by the Engineer.

The Engineer will test the core samples for density.

The Engineer will perform or witness the measurement of the depth of the asphalt binder in the storage tanks as described in SD 314. The Engineer will determine the temperature of the asphalt binder in the tank and will perform the daily calculation of the asphalt binder content.

The Engineer will perform the daily calculation of the hydrated lime content.

The Engineer will test the moisture content of the hot mix. The mix for the moisture test shall be sampled from the windrow in front of the laydown machine and placed in an airtight, tared container. The mix shall be dried to a constant mass as described in SD 305.

F. Independent Assurance Procedures: The Department will perform Independent Assurance (IA) testing on project produced materials. Random samples of mineral aggregate and hot mix asphalt concrete used for QC testing will be selected by the Region Materials Engineer for independent testing. IA testing will be performed at a minimum frequency of one per 10,000 tons (M ton).

The Region Materials Engineer will perform IA testing for the attributes listed in Table L. The tolerances from Table L will be used to independently evaluate the QC and QA testing procedures and equipment. The Region Materials Engineer shall witness the sampling and splitting of the designated IA sample (an actual sublot sample). The Region Materials Engineer may select either Engineer or Contractor sampled sublot for the IA testing.

The Region Materials Engineer will also perform IA testing for the bulk specific gravity on in place density cores. A separate IA core shall be obtained by the Contractor while obtaining the in place density core used to determine the pay factor. The IA core shall be taken at the same offset and within one foot of the core used in determining the pay factor. An IA core must be taken during the first 5,000 (M ton) tons of hot mix tested for in place density and then at a minimum frequency of one core per 10,000 tons (M ton) thereafter. A tolerance of 0.020 will be used to evaluate the bulk specific gravity of the in place density cores.

G. Dispute Resolution System: If the differences between the QC and QA results are greater than allowed in Table L or SD 317, the Engineer will investigate the reason for the difference. The investigation may include review and observation of test procedures and equipment. The QA technician shall test the next QC sample as soon as a difference between any QC and QA test result is found. The Engineer may require that a sample be tested jointly by the Contractor's QC technician, the Engineer's QA technician, and the Region Materials Engineer. The Region Materials Engineer test results and/or Central Office Materials Lab test results will be the referee used for acceptance and will determine which sample test results will be incorporated into the pay factor calculations only when a dispute between the QA and QC sample cannot be resolved. Process verification procedures using F-test and t-test statistical evaluation procedures to determine if both QC and QA test results represent the same sample population may result in the need for testing backup sublot samples and substituting the new test result for pay factor calculations. If the QC and QA test results do represent the same population, as determined by F-test and t-test statistical evaluation procedures, the Contractor’s test results may be used for quality acceptance.

H. Preparation of the Mixture: The mineral aggregate shall be satisfactorily mixed with the proper quantity of asphalt binder at the central mixing plant. The asphalt binder shall be added and the mix produced at the temperatures established by the job mix formula.

The mixing plant shall be operated using automatic controls. Manual operation will be permitted for the remainder of the day when automatic controls fail, provided specified results are obtained. The Contractor shall restore the automatic operation prior to the next day’s resumption of paving operations.

In batch plants, the mineral aggregate shall be mixed dry for a minimum of five seconds.

After introducing the required aggregate and asphalt into the mixer the materials shall be continuously mixed until the aggregate is completely and uniformly coated and a thorough distribution of the asphalt binder throughout the aggregate is obtained.

When hot mix storage bins are used, storage of the asphalt mix shall be limited to a maximum of 15 hours. The point of temperature measurement will be the discharge end of the mixer.

I. Transportation and Delivery of the Mixture: The mixture shall be transported from the plant to the point of use in pneumatic tired vehicles. The vehicle boxes shall be tight, clean, and smooth. Boxes shall be cleaned only with release agents such as lime water, soap, a detergent solution, or a commercial product specifically intended for this use. Oils, diesel fuel, or other petroleum solvents shall not be used. No material shall be used which could adversely affect the asphalt concrete mixture. Excess solution in the box shall be disposed of before the vehicle is loaded.

Loads shall be tarped in inclement weather conditions and when directed by the Engineer.

J. Tacking, Spreading, and Compacting: The surface, including all vertical contact faces on which the asphalt concrete is to be placed, shall be tacked according to Section 330. The tack coat shall be allowed a cure period, as determined by the Engineer, prior to asphalt concrete placement.

Surfaces which have been primed with cutback asphalt shall be allowed to cure for a minimum of 72 hours prior to being overlaid with asphalt concrete.

Asphalt concrete shall be placed by self-propelled pavers. Handwork is permissible in inaccessible or odd shaped areas. In lieu of a self-propelled paver, asphalt concrete may be placed by a shouldering machine on shoulders less than 6 feet (2 m) in width.

Spot leveling and repair of the existing surface with asphalt concrete shall be required prior to the paver laid courses at locations designated. Potholes and areas of localized disintegration shall be cleaned of loose material, squared, tacked, leveled with asphalt concrete, and satisfactorily compacted. Spot leveling may be blade laid in lifts not exceeding three inches (75 mm) of uncompacted depth. Compaction shall be by the specified roller coverage method, except a steel face roller will not be required.

Paver laid mix shall be spread using automatic transverse and longitudinal grade controls. If the automatic controls fail or malfunction, the Engineer may permit manual operation the remainder of the day, provided the finished product meets the specifications. Frequent breakdowns will be cause for suspension of the work by the Engineer until repair or replacement is made.

Following placement of the first pass using the traveling stringline for control, adjacent passes and succeeding lifts shall be placed using the traveling stringline riding on the previously laid material. A shoe attachment may be used to match the longitudinal

joint(s) on the final paver pass(es) of the top lift unless otherwise directed by the Engineer.

A shoe attachment on the paver shall be used to automatically match the elevation of asphalt concrete shoulders with concrete pavements.

Automatic slope controls will be required on paving equipment used to pave asphalt shoulders that are 8 feet (2.4 m) or more in finished width.

Asphalt concrete shall be placed directly in a uniform windrow and then fed into the paver by a paver feeder. The use of a paver feeder is not required on shoulders, turning lanes less than 500 ft (150 m), roadway paving less than 500 ft (150 m), and transitions into bridge decks less than 500 ft (150 m). The paver feeder shall pick up substantially all of the mix and feed it into the paver without segregation. The size of the windrow shall be regulated so that the paver is fed a continuous and adequate supply of mix. The screed shall not be raised solely to accommodate excess material in the windrow or paver hopper. A Material Transfer Vehicle (MTV), which takes material directly from the trucks, stores and mixes it, and then dumps into the paver hopper, may be used if approved by the Engineer.

On the final surfacing lift laydown operations shall commence at the farthest point and progress continuously toward the plant.

On rural projects, a partial width pass may be extended beyond the adjacent pass by as much as one days run. The paver shall be moved back the following working day to place the adjoining pass. Where a difference in elevation exists between two lanes carrying traffic in the same direction on rural multi-lane asphalt concrete construction, one of the effected lanes shall remain closed to traffic.

The plant production and availability of hauling vehicles shall be sufficient to provide a uniform and consistent quantity of asphalt concrete to the paver so laydown operations are continuous. Stops and starts shall be restricted to a minimum. Stopping normal laydown operations to surface an approach, thereby creating an unnecessary joint, will not be permitted.

Laydown operations shall proceed from the center to the shoulders of the roadbed surface. When turning lanes are present, the Contractor may alter the laydown operation. The Contractor shall submit his proposed laydown operation to the Engineer for prior approval. The center joint of the top lift shall be located on centerline. Longitudinal joints below the surface shall be offset from the previously constructed joints by approximately 6 in. (150 mm) and be located within 12 in. (300 mm) of the lane line. In curb and gutter sections, laydown may proceed from the gutter line to the centerline.

Transverse joints in the final lift shall be formed by sawing back the previous run to expose the full depth of the course. The finished transverse joint of all lifts shall have a uniform texture and comply with the straightedge requirement. Waste material resulting from forming joints and temporary ramps shall be removed and disposed of by the Contractor.

Segregation or excessive pulling of the mix shall warrant suspension of operations.

Immediately after the mix has been placed and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling.

Vibratory rollers shall have an automatic shutoff to deactivate the vibrators when the roller speed is less than 0.5 mph. They shall operate according to the manufacturer's recommendations for speed, impacts per foot, and amplitude of vibration for the thickness of mix being compacted. Rolling shall be longitudinal, commencing at the outer edges of the mat and progressing toward the center in straight, parallel strips, overlapping at least six inches (150 mm). On superelevated curves, rolling shall progress from the lower to the upper edge of the mat. The Contractor shall vary the points of reversal to prevent a transverse crease. The rollers shall not stand idle on any part of the mat that has not been compacted and cooled sufficiently to resist deformation.

The shoulders shall be compacted using the same roller pattern used on the adjacent mainline asphalt concrete or as directed by the Engineer. The beveled edge shall be satisfactorily compacted.

Longitudinal joints shall be compacted in accordance with the following:

For confined edges, on the first pass adjacent to the confined edge; the compaction equipment shall be entirely on the hot mat 6 in. (150 mm) from the longitudinal joint.

For unconfined edges, on the first pass adjacent to the unconfined edge, the compaction equipment shall extend 6 in. (150 mm) beyond the edge of the mat.

The surface of each lift shall be free of waves and other irregularities. The final lift surface shall be checked with a ten foot (three meter) straightedge. The variation of the surface from the straightedge between any two contact points shall not exceed 1/4 inch (6 mm). The crown, on all lifts, as indicated by checking with a ten foot (three meter) straightedge, shall be within 0.04 foot (12 mm) of specified crown in any ten foot (three meter) length.

Irregularities shall be corrected before the temperature of the asphalt mix drops below 175º F (80º C). The longitudinal profile can only be improved by using a grinder with diamond blades mounted on a horizontal shaft and when approved by the Engineer. Areas that have been ground shall not be left smooth or polished, but shall have a uniform texture equal in roughness to the surrounding unground asphalt concrete. Grinding shall be daylighted to the outside edge of the pavement. Ground surfaces shall be flushed sealed. Under no circumstances shall operations continue when it becomes evident final rolling is not producing a smooth, uniform, compacted surface free from roller marks and other irregularities.

The mix shall be compacted by one of the following methods: Unless otherwise specified, the specified density method shall be used.

1. **Specified Density Method:** The mix shall be compacted to the density specified. Compaction rolling shall be completed before the temperature of the mix drops below 175°F (80°C). Vibratory rollers may only be used in the static mode for finish rolling.

   Compaction of mix placed on farm entrances, residences, businesses, and intersecting road approaches shall be compacted by the specified roller coverage method.

2. **Specified Roller Coverage:** The mix shall be compacted by at least four complete coverage's with pneumatic tired rollers (a minimum of 60 inches wide [1500 mm] and weighing at least 250 pounds per inch [4.5 kilograms per millimeter] of roller width) and at least one complete coverage with steel faced rollers, or as approved by the Engineer. The steel faced rollers used for specified roller coverage shall be the same as the rollers used for mainline compaction or similar rollers of equal size (weighing at least 325 pounds per linear inch [5.8 kilograms per millimeter] of roller width).

   Breakdown rolling may be accomplished by using steel-faced rollers, only when approved by the Engineer.

   Rolling shall proceed on the mat as soon as lay down is completed. Completion of rolling on any segment shall not lag behind the laydown more than 1000 feet (300 meters). During periods of cool weather this maximum distance between laydown and final rolling shall be reduced as directed by the Engineer.

   Compaction to a specified density will not be required. However, additional roller coverage may be required to obtain a smooth surface finish.

   When directed by the Engineer, the Contractor shall cool, saw, and remove an undamaged, 6 inch (150 mm) square sample or a 6 inch (150 mm) diameter round sample from a designated area and repair the hole to the satisfaction of the Engineer. The Engineer shall take immediate possession of all samples for further testing.

K. Maintenance: The Contractor shall maintain the work during construction and until final acceptance. Maintenance shall include protection and repair of the prepared base course, tack coat, wearing surface mat, shoulders, and seal course. Rich or bleeding areas, breaks, raveled spots, or other nonconforming areas in the wearing surface or base shall be corrected.

L. Traffic Control: Hauling or allowing traffic on the roadway will not be permitted until the surface has been compacted and cooled sufficiently to resist marking or distortion.

Where traffic is to be maintained by means of part width construction, the Contractor shall control all traffic by identified pilot cars and flaggers. The Contractor shall schedule work so traffic will not be greatly inconvenienced with long one-way lanes.

M. Shoulder Joints: When specified a continuous groove shall be constructed by forming, sawing, or routing the joint between the Portland cement concrete pavement and the asphalt concrete shoulder.

Sawing may be done with either diamond or water-cooled abrasive blades.

If a router is used it must be capable of cutting a groove to the required dimensions. Equipment designed to plow the groove to dimension will not be permitted. The walls of the finished groove shall be vertical and the groove bottom shall be flat.

The groove shall be thoroughly cleaned immediately after forming, sawing, or routing. Dry sawed joints shall be cleaned with high-pressure air. Wet sawed joints shall be cleaned with high-pressure water followed by high-pressure air. The air compressor shall produce a minimum of 125 CFM (0.06 cubic meters per second) output and shall be equipped with a maximum 3/4 inch (20 mm) nozzle. The groove (including the sides) shall be free of dirt, dust, water, oil, grease, and loose material immediately prior to sealing. The Portland cement concrete surface shall be free of asphalt and any curing compound that would prevent bonding. The groove shall be completely dry and filled level with joint sealer by a sealing device, which will not entrap air in the sealed joint.

Joint sealer application will not be permitted when the air temperature near the joint is less than 40^{o} F (5^{o}C) or is 40^{o} F (5^{o}C) and falling.

320.4 METHOD OF ACCEPTANCE AND MEASUREMENT

A. Asphalt Binder: Asphalt binder will be measured to the nearest 0.1 ton (M ton). Quantities of asphalt binder in excess of the asphalt content listed on the job mix formula plus 0.3% tolerance will not be accepted for payment.

.

B. Asphalt Concrete: The asphalt concrete shall be statistically accepted by lots. A lot shall consist of five sublots. Sublots shall not represent more than 1000 tons (M ton) unless the current sublot is terminated. The first lot shall start at the beginning of production or following the Control Test Strip.

A lot will be terminated when a new job mix formula is issued. If less than five sublots have been completed when a lot is terminated, the sublots will be included in the previous lot and the pay factor computed for the revised lot. If there is no previous lot, the lot will not be terminated until five sublots are obtained.

1. Determination of Contract Unit Price Adjustment: Asphalt concrete that is not compacted according to the Specified Density Method will not be included in the pay factor calculations. The material specified to be sampled and tested on a QC/QA basis will be evaluated for payment under this subsection. All QC test results for a lot will be analyzed collectively and statistically by the Quality Level Analysis-Standard Deviation Method using the procedures herein defined. The lots will be analyzed to determine the total estimated percent of the lot that is within the specification limits.

Quality Level Analysis (specification conformance analysis) is a statistical procedure for estimating the percent of material that is within the specification limits (PWL). The PWL is determined by using the lot mean, ($\overline{X}$) and the lot standard deviation (s). Two measures of quality are required to establish the contract unit price adjustment. The first measure is the Acceptable Quality Level (AQL) which is the PWL at which the lot will receive 100 percent pay or a composite pay factor of 1.00. The second measure of quality is the Rejectable Quality Level (RQL) at which the Engineer has determined the material may not perform as desired and may be rejected.

The AQL has been selected at 90 PWL and the RQL at 60 PWL. The RQL using the pay factor equation will result in 85 percent pay or a pay factor of 0.85.

An individual pay factor for any attribute resulting in less than 85 percent pay may result in the lot being rejected.

When the Acceptable Quality Level of any individual pay factor attribute has a QL of 90 or less the composite pay factor shall not exceed 1.00.

A lot may be accepted provided the composite pay factor is at least 0.85 and there are no isolated defects identified by the Engineer.

A lot containing material with less than a 0.85 composite pay factor may be rejected. All of the rejected material shall be removed from the work. The Engineer will determine if the material may remain in place at a reduced price.

The Engineer may reject any quantity of material that appears to be defective based on visual inspection or test results. The visual rejection may include segregation, low temperature material, very high or low asphalt content, etc. Such rejected material shall not be used in the work or included with the lot acceptance tests. Rejected material will not be measured for payment.

The Contractor may elect to remove any defective material and replace it with new material to avoid a pay factor less than 1.00. Any such new material will be sampled, tested, and evaluated for acceptance according to this specification.

2. Quality Level Analysis: The standard deviation method procedures are as follows:

a. Only test results on material incorporated in the work will be included in the quality level analysis.

b. Calculate the arithmetic mean ($\overline{X}$) of the test values:

$$\overline{X} = \frac{\Sigma x}{n}$$

Where: Σ = summation of
x = individual test value to x_n

n = total number of test values

c. Calculate the sample standard deviation(s):

$$S = \sqrt{\frac{n\Sigma(x^2) - (\Sigma x)^2}{n(n-1)}}$$

Where: $\Sigma(x^2)$ = summation of the squares of individual test values.

$(\Sigma x)^2$ = summation of the individual test values squared.

d. Calculate the upper quality index (Q_U):

$$Q_U = \frac{USL - \overline{X}}{s}$$

Where: USL = upper specification limit or target value (TV) plus allowable deviation.

Target Value = the single specification value which would result in an ideal product.

e. Calculate the lower quality index (Q_L):

$$Q_L = \frac{\overline{X} - LSL}{s}$$

Where: LSL = lower specification limit or target value minus allowable deviation.

f. Determine P_U (percent within the upper specification limit which corresponds to a given Q_U) from Table R.

Note: If a USL is not specified, P_U will be 100.

g. Determine P_L (percent within the lower specification limit which corresponds to a given Q_L) from Table R.

Note: If an LSL is not specified, P_L will be 100.

h. Determine the Quality Level (the total percent within specification limits).

Quality Level (QL) = $(P_U + P_L) - 100$

i. To determine the pay factor for each individual attribute (PF) = 55 + 0.5(QL).

j. Determine the Composite Pay Factor (CPF) for each lot. The third decimal place of the CPF shall be rounded to the nearest hundredth by the computer program.

$$CPF = \frac{[f_1(PF_1) + f_2(PF_2)]}{(100)\,\Sigma f}$$

f = 1 to 2

Where: $f_{1 \text{ or } 2}$ = price adjustment factor listed in Table Q for each measured attribute.

$PF_{1 \text{ or } 2}$ = Pay Factor for each measured attribute.

Σf = Sum of the "f" (price adjustment) factors.

The asphalt concrete pavement contract unit price will be adjusted according to Section 320.4 of this specification. Payment for the asphalt concrete will be made at a price determined by multiplying the contract unit price by the composite pay factor. The following table will be used to calculate the composite pay factor:

Table Q - Pay Attributes & Price Adjustment Factors

Measured Attribute	Factor "f"
Design Air Voids	50
In Place Density (% Compaction)	50

All mineral aggregate testing prior to production and QC/QA testing shall be incidental to the contract unit price per ton for asphalt concrete.

Asphalt concrete will be measured to the nearest 0.1 ton (M ton). The mixture of mineral aggregate and asphalt will be weighed after mixing. No deduction will be made for the weight of the asphalt included in the mixture.

Deduction will not be made for material removed from temporary approaches. Deductions will be made for all rejected asphalt concrete pavement.

C. Hydrated Lime: Hydrated lime, when provided as an additive to the asphalt concrete mixture to meet the moisture sensitivity requirements, will be measured to the nearest 0.1 ton (M ton). Quantities of hydrated lime in excess of the lime content listed on the job mix formula plus 0.1% tolerance will not be accepted for payment.

D. QA and QC Field Laboratories: There will be no measurement or payment for the QC laboratory furnished and used by the Contractor to perform the QC testing. The Contractor furnished QA laboratory will be measured on a per each basis.

E. Sawing and Sealing Shoulder Joints: Field measurement for this work will not be required. Plan quantity will be the basis of payment. If changes are ordered by the Engineer, the length will be measured and the quantity changed.

320.5 BASIS OF PAYMENT

A. Asphalt Binder: The accepted quantities of asphalt binder will be paid for at the contract unit price per ton (M ton). The amount bid for this item shall be at least the cost of the asphalt binder furnished and delivered to the project site.

Payment for the asphalt binder is not subject to the statistical pay factor adjustment. The asphalt concrete is subject to removal or price adjustment.

B. Asphalt Concrete: The accepted quantities of asphalt concrete, will be paid for at the contract unit price as adjusted by the pay factor calculations in Section 320.4 of this specification per ton (M ton) complete and accepted in place.

Asphalt concrete that is not compacted according to the Specified Density Method will not be included in the pay factor calculations. Asphalt concrete that is not included in the pay factor calculations shall be paid for at the contract unit price per ton (M ton).

The contract unit price of asphalt concrete shall include all cost for labor, equipment, materials, testing, and all incidentals required to furnish and place the asphalt concrete mix according to these specifications.

C. Hydrated Lime: Hydrated lime will be paid at the contract unit price per ton (M ton) complete in place. Payment for hydrated lime will only be made when hydrated lime is actually used. The amount bid for this item shall be at least the cost of the hydrated lime furnished and delivered to the project site.

D. Laboratories:

1. **QC Laboratory:** The laboratory used by the Contractor for QC testing shall be incidental to the asphalt concrete pavement item(s).

2. **QA Laboratory:** Payment for the QA laboratory will be according to Section 600 of the Standard Specifications.

E. Sawing and Sealing Shoulder Joints: Sawing and sealing shoulder joints will be paid for at the contract unit price per foot (meter).

Refer to Table R for the upper quality and lower quality index data for use in the pay factor calculations.

TABLE R - QUALITY LEVELS
QUALITY LEVEL ANALYSIS BY STANDARD DEVIATION METHOD

P_u or P_l Percent Within Limits for Positive Values Of Q_u or Q_l	UPPER QUALITY INDEX Q_U OR LOWER QUALITY INDEX Q_L														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to n=∞
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99		1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97		1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95		1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93		1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.52
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NOTE: For negative values of Q_U or Q_L, P_U or P_L is equal to 100 minus the table P_U or P_L. If the value of Q_U or Q_L does not correspond exactly to a figure in the table, use the next higher value.

* * * * *