

2331

2331

Plant Mixed Bituminous Pavement

2331.1 DESCRIPTION

This work shall consist of constructing one or more pavement courses of hot plant mixed bituminous-aggregate mixture on a prepared surface.

2331.2 MATERIALS

A Aggregate 3139

For drum mix, screenless continuous mix, and screenless batch mix plants, the Contractor shall provide a minimum of two non-segregated, non-asphaltic aggregate stockpiles sufficiently different in gradation to control mixture properties (percent air voids, gradation, percent crushing, aggregate quality, and asphalt content) within specified limits.

Also, the aggregate with the largest percentage for Type 61 mixture shall be split into separate stockpiles sufficiently different in gradation to provide control of mixture properties within specified limits. Split stockpiles are not required for aggregate containing 100 percent taconite tailings.

The Contractor may incorporate any of the above aggregate material into the mix at any desired percentage to maintain, or to bring production quality control within the Specification limits without redesign of the mixture. No adjustments are allowed using aggregate sources not part of the original mix design.

If 100 percent of the aggregate for Type 31C mixture (3139.2) passes the 19.0, 25.0 or 37.5 mm (**3/4, 1 or 1-1/2 inch**) sieve, the approved paving lift thickness will be twice the maximum particle size.

B Bituminous Material..... 3151

The binder material shall meet the requirements of PG asphalt binder testing tolerances, sampling rates, testing procedures, and acceptance criteria based on the most current Mn/DOT Technical Memorandum, titled, "Inspection, Sampling, and Acceptance of Bituminous Materials." The PG asphalt binder cannot be modified with air blowing procedures unless it is approved by the Mn/DOT Bituminous Office. The Contractor shall not use petroleum distillates such as fuel oil, diesel fuel or other fuels in the asphalt tanks.

C Additives

An additive is any material added to a bituminous mixture or material, such as mineral filler, hydrated lime, asphalt additives, and similar products, that does not have a specific pay item. When a Contract requires additives, compensation is included with the pay items for the appropriate mixture. If the Engineer directs the Contractor to incorporate these additives, the compensation will be as Extra Work.

2331.3

The Department will not compensate the Contractor for additives incorporated at the Contractor's option.

Additives shall not be incorporated into the mixture without approval of the Bituminous Engineer. Anti-foaming agent shall be added to asphalt cement at the manufacturer's recommended dosage rate. Mineral filler and hydrated lime may be added in a quantity not to exceed 5 percent and 2 percent, respectively, of the total mass of the aggregate. The combination of mineral filler and hydrated lime shall not exceed 5 percent of the total mass of aggregate. The Engineer will approve or disapprove methods for addition of additives.

| | | |
|----------|---|---------------|
| C1 | Mineral Filler..... | 3145 |
| C2 | Hydrated Lime | 3106 |
| C3 | Coating and Anti-Stripping Additive | 3161 |
| D | Bituminous Tack Coat..... | 2357.2 |

2331.3 CONSTRUCTION REQUIREMENTS

A General

The following construction requirements provide for the construction of base, binder, leveling, wearing, and shoulder wearing courses.

When construction is under traffic, the requirements of 2221.3D will apply.

B Restrictions

Bituminous mixtures shall not be placed when, in the opinion of the Engineer, the weather or roadbed conditions are unfavorable.

In general, no work within the roadway will be permitted in the spring until seasonal load restrictions on roads in the vicinity have been removed. However, work within the roadbed may be permitted before that time if, in the opinion of the Engineer, it can be done without damage to the subgrade.

No Type 61 wear (Table 2331-1A) bituminous mixture shall be placed after September 1st in that portion of the State north of an east-west line between Browns Valley and Holyoke, nor after September 15th south of that line.

No traffic shall be allowed on Type 61 wearing course for 12 hours after placement, or until the surface temperature has dropped to 60°C (140° F), or as directed by the Engineer. The surface temperature may be lowered by flushing with water.

No bituminous pavement wearing course shall be placed after October 15th in that part of the state north of an east-west line between Browns Valley and Holyoke, nor after November 1st south of that line. The Engineer may waive these restrictions when:

- (1) The bituminous mixture is not being placed on the traveled portion of the roadway, or

2331.3

- (2) The roadway involved will not be open to traffic during the following winter, or
- (3) The Engineer directs in writing that the mixture be placed.

The Contractor shall not use petroleum distillates such as kerosene and fuel oil to prevent adhesion of bituminous mixtures in paver hoppers, truck beds, or on the contact surfaces of the compaction equipment.

The Contractor shall only use the anti-adhesive agent that is on the approved list on file with the Bituminous Engineer.

C Equipment

C1 Bituminous Mixing Plants

C1a Requirement for All Plants

The mixing plant shall have sufficient capacity and coordination capability to produce bituminous mixture at a rate commensurate with the construction and completion requirements of the Contract.

The mixture shall meet all applicable requirements for gradation, asphalt content, percent air voids, mixing time, and coating.

The Contractor shall test and calibrate all scales according to 1901 except as otherwise designated.

C1a(1) Preparation of the Aggregate

The plant site shall have sufficient storage space and facilities to keep different materials separated until delivered in proper sequence and proportions to feeders for blending or mixing. The Engineer will approve or disapprove storage facilities. Storage facilities shall be readily accessible for sampling.

For batch plants and continuous plants, mineral filler other than rock screenings shall be fed proportionately to the hot aggregate before it is introduced into the mixer. For a drum mix plant, the mineral filler shall be added proportionally prior to introduction into the mixer. When using a silo for storage of mineral filler, the silo shall be equipped with a vibrator or other device to ensure a constant and uniform feed. If rock screenings are used as mineral filler, the screenings shall be added separately to the cold feed as an addition to the aggregate for bituminous mixture. The feeder for supplying rock screenings shall be mechanical and able to maintain an accurate and uniform rate of feed within 1 percentage point of the required proportion.

The plant shall have a mechanical means for uniformly feeding the aggregates into the dryer and shall provide uniform production and temperature. When aggregates must be blended from two or more bins at the cold feed to meet the requirements of the paving mixture specifications, a synchronized proportioning method shall be provided that can easily and accurately be calibrated.

2331.3

Each different material (source, class, kind, or size) shall be fed at a uniform rate from its storage unit. An individual source, class, type, or size of material shall not be stockpiled blended with another source, class, type, or size of material.

The Engineer may require a scalping screen mechanism to control the maximum particle size in the final mixture. This device may be used either before or after drying of the aggregate. Salvaged asphaltic aggregate need not be dried prior to entry into the mixer.

C1a(2) Equipment for the Preparation of Bituminous Material

Tanks for storage of bituminous material shall be equipped to heat the material and maintain the material at the required temperatures. The heating shall be accomplished by steam coils, electric units, or other approved means. No flame shall be in contact with the tank. The circulating system for the bituminous material shall be designed to ensure proper and continuous circulation during the operating period. The discharge end of the circulating line shall be below the surface of the bituminous material.

An outage table or chart and measuring stick shall be provided for each storage or working tank. Tanks shall be equipped with provisions for taking of bituminous material samples.

After delivery of bituminous material to the Project, the Contractor shall not heat the material above 175°C (**350° F**). When proportioned by volume, the temperature of the asphalt shall be within 5°C (**9° F**) of the calibration temperature.

C1a(3) Bituminous Control

When bituminous material is proportioned by volume, the plant shall be equipped with either a working tank or a metering system for determining bitumen content of the mixture.

The working tank shall have a capacity between 3800 L and 7600 L (**1000 and 2000 gallons**). The working tank shall be calibrated and supplied with a calibrated measuring stick. The tank may be connected to a mixing unit and used only during spot check operations, but it shall be available at all times. Any feedback shall be returned to the working tank during spot check operations.

The metering system shall consist of at least one approved bitumen flow meter in addition to the bitumen pump. The flow meter shall be connected to the bitumen supply to measure and display only the bitumen being fed to the mixer unit. The meter readout shall be positioned for convenient observation. Means shall be provided for comparing the flow meter readout with the calculated output of the bitumen pump. In addition, the system shall display in liters (**gallons**) or to the nearest 0.001 metric ton (**0.001 ton**), the accumulated bitumen quantity being delivered to the mixer unit. The system shall be calibrated and adjusted to maintain accuracy not exceeding 1 percent error.

2331.3

C1a(4) Dryer

A dryer shall be capable of drying and heating the aggregate to the moisture and temperature requirements of the mixture. The aggregate shall be free of unburned fuel. The dryer (including the dryer portion of drum-mix plant) shall dry the aggregate to provide a moisture content not greater than 0.5 percent. The moisture content in the mixture shall be measured behind the paver and tested in accordance with the procedure listed in the Mn/DOT Bituminous Manual.

C1a(5) Thermometric Equipment

The plant shall be equipped with a sufficient number of thermometric instruments to ensure temperature control of the aggregate and the bituminous material. The actuating unit for the bitumen temperature shall be located either in the storage tank or the bitumen line between the pump and the charging valve. The actuating unit for the aggregate temperature shall be located on the discharge chute of the dryer or in the fine aggregate hot bin.

C1a(6) Pollution Controls

C1a(6)a Pollution 1717

C1a(6)b Dust

The plant shall be equipped with a dust collecting system that will either waste the dust or return all or part of it uniformly to the plant.

C1a(7) Surge and Storage Bins

The plant may include facilities to store hot bituminous mixture for coordinating the rate of production with the paving operations. Storage of the hot mixture will be permitted for a period not to exceed 18 hours, provided the following requirements are met:

- (a) Hot mix storage facilities shall be designed and operated to prevent segregation of the mix, drainage of the asphalt from the mix, and excessive cooling or overheating of the mixture.
- (b) The temperature of the mixture at time of discharge from the storage facility shall be within a tolerance of 5°C (9° F) of the temperature when discharged from the mixer.

If the mixture is held in storage longer than 18 hours, it may be used only if approved by the Engineer.

C1b Requirements for Plants Controlling Gradations of Hot, Dry Aggregate

C1b(1) Screens

When plant screens are used to separate the hot aggregate into fractions for gradation control, the screens shall have capacity in excess of the full capacity of the mixer and they shall be capable of screening the aggregates to the specified sizes and proportions. The screens shall be operated to provide a uniform quantity of material so that less than

15 percent of the finer fraction is carried over into the next larger fraction.

C1b(2) Bins

The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to ensure separate and adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for mineral filler when used.

Each bin shall have an overflow pipe of sufficient size and shall be located to prevent backing-up of the material into other bins.

C1c(1) Cold Feed Bins

Adequate and convenient facilities shall be provided for diverting aggregate flow into trucks or other suitable containers to check the accuracy of the aggregate delivery system.

C1d Requirements for Batch Plants

C1d(1) Scales..... 1901

Aggregate scales for any weigh box or hopper may be either the beam, springless dial or digital readout type and shall be a standard make and design, accurate to 0.50 percent of the maximum required load. The Engineer may allow new technology.

Beam type aggregate scales shall have a separate beam for each size of aggregate. Each scale shall have a locking device designed and located so the beam can easily be suspended or thrown into action. The knife edges and fulcrums shall be clean. A telltale dial shall be provided with a sensitivity of at least 25 mm per 5 kg (**1 inch per 10 pounds**), which will begin to function when the applied load is within 50 kg (**100 pounds**) of the load to be weighed. Sufficient vertical movement of the beams shall be provided to permit the telltale dial to function properly.

Dial type aggregate scales shall have dials of the compounding type, with full complements of index pointers placed to give minimum parallax errors. All dials shall be placed in a location plainly visible to the operator at all times. The dials shall read to 5 kg (**10 pounds**) increments.

Scales for weighing bituminous materials shall conform to the above requirements for aggregate scales except that:

- (a) Beam type scales shall have a tare beam and a full capacity beam with minimum graduations of not more than 1 kg (**2 pounds**).
- (b) The dial shall have a sensitivity of at least 25 mm per 2.5 kg (**1 inch per 5 pounds**) and shall begin to function when the load being applied is within 10 kg (**25 pounds**) of the load to be weighed.
- (c) Dial scales shall read to the nearest 0.5 kg (**pound**).

2331.3

C1d(2) Weigh Box or Hopper

The equipment shall include a means for accurately weighing each size of aggregate in a weigh box or hopper suspended on scales. The weigh box or hopper shall be sufficient in size to hold a full batch without hand raking or running over. It shall be supported on fulcrums or knife edges. All edges, ends, and sides of weighing hoppers must be free from contact with any supporting rods or columns or other equipment. There must be sufficient clearance between the hopper and supporting devices to prevent accumulation of foreign materials. The discharge gate of the weigh box shall be hung to prevent segregation of the aggregate when dumped into the mixer. The gate shall close tightly when the hopper is empty so no material will be allowed into a batch in the mixer during the process of weighing the next batch.

If the hot aggregate is not separated into fractions by screening, discharge into the weigh hopper shall be made from one bin only, and this shall be done without affecting the accuracy of the weighing. The quantity of aggregate stored in the bin at any time shall be limited to prevent segregation of the aggregate.

C1d(3) Bituminous Control

When controlled by mass, the bituminous material bucket shall be a non-tilting type provided with a cover, and the length of the discharge opening or spray bar shall not be less than three-fourths the length of the mixer and shall discharge directly into the mixer.

When controlled by volume, the volumetric proportioning device for the bituminous material shall be a rotating, positive displacement, bitumen pump. Discharge at the mixer shall be through a satisfactory spray nozzle arrangement. The metering system shall be installed between the metering pump and the spray bar.

C1d(4) Mixer Unit for Batch Method

The mixer shall be a twin pugmill type, steam or oil jacketed, capable of producing a uniform mixture within the Contract tolerances. It shall have a batch capacity of not less than a metric ton (**ton**). The mixer shall be constructed to prevent leakage of contents until the batch is discharged.

The mixer paddles (or blades) shall be set so that the mixture will move both parallel to and around the shafts. The clearance of blades from all fixed and moving parts shall not exceed 20 mm (**3/4 inch**).

C1d(5) Control of Mixing Time

The plant shall be equipped with a timer as well as a horn, a bell, or lights to indicate the completion of a mixing cycle.

C1d(6) Automatic Batching Controls

All batch plants shall be fully automated to the extent that the only manual operation required for proportioning of all materials for one batch shall be a single actuation of a switch or starter.

C1e Requirements for Continuous Mixing Plants

C1e(1) Aggregate Proportioning Unit

The plant shall include means for accurately proportioning the aggregate by volumetric measurement.

The unit shall include a feeder mounted under the aggregate compartment. The feeder shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material. The feeding orifice shall have adequate dimensions to provide a positive feed without bridging. One dimension shall be adjustable by positive mechanical means and have a lock. Graduated indicators with subdivisions of 5 mm (**1/4 inch**) or less shall be provided on the gate or gates to show the sizes of gate opening.

C1e(2) Calibration of Aggregate Feed

The plant shall include a means for calibration of gate openings by weighing test samples. The materials fed out of each bin shall pass through individual orifices to separate test boxes. An accurate platform scale with a minimum capacity of 225 kg (**500 pounds**) shall be provided.

C1e(3) Bituminous Control

The volumetric proportioning device for the bituminous material shall be a rotating, positive displacement, bitumen pump. Discharge at the mixer shall be through a satisfactory spray nozzle arrangement. The metering system shall be equipped with a pressure gauge of sufficient size to accurately indicate spray nozzle pressure. The pressure gauge shall be installed between the metering pump and the spray bar.

C1e(4) Synchronization of Aggregate Feed and Bitumen Feed

The feeding of aggregate and bituminous materials into the mixer shall be synchronized by interlocking mechanical means or other positive method approved by the Engineer.

The plant shall be equipped with an accurate revolution counter mounted on the aggregate feed apron to the mixer.

C1e(5) Bins

Each bin shall be equipped with either:

- (a) A telltale device that will emit an adequate sound or light indicating an insufficient supply of aggregate, or
- (b) An actuating device that will automatically shut off the plant operation when the aggregate supply in any bin reaches below a minimum set level.

The storage in each bin shall be limited in quantity so that sloughing or segregation will not occur. If more than one bin is used, separation of aggregate fractions shall be accomplished to ensure uniform flow to each bin and to preclude segregation of the total material obtained from the individual bins.

2331.3

C1e(6) Mixer Unit

The plant shall include a continuous mixer of the twin pugmill type, capable of producing a uniform mixture. The angular position of the paddles on the shafts shall be adjustable and reversible to retard the flow of the mix. The paddle clearance shall be less than 50 mm (**2 inches**). A manufacturer's plate shall state the net volumetric contents of the mixer at various heights.

The mixer shall be equipped with an approved surge or storage bin at the discharge end of the pugmill.

C1f Requirements for Drum-Dryer Mixing Plants

C1f(1) Hot Mix Storage

Hot mix storage facilities provided for in 2331.3C1a(7) shall be furnished.

C1f(2) Thermometric Equipment

The provisions of 2331.3C1a(5) shall only apply to bituminous material temperature control.

C1f(3) Mixer Unit

The heating, coating, and mixing of the bituminous mix shall be accomplished in an approved parallel flow, counter flow, or double barrel dryer-mixer. Heating shall be controlled to prevent degradation to the aggregate and bitumen. The system shall be equipped with automatic burner controls providing for temperature sensing of the bituminous mixture at discharge. The system shall be interlocked to stop all feed components if either the aggregate or asphalt feed stops.

C1f(4) Synchronization of Aggregate and Bitumen Feed

A protection switch shall be provided to stop the aggregate feed and the bitumen feed if the material from any aggregate feed stops flowing.

The cold feed elevator shall be equipped with a continuous weighing system with a recorder that can be monitored by the plant operator. The weighing system shall be automatically coupled with the bitumen flow to maintain the required proportions. The weighing system shall have provisions to enable easy calibration without having the material enter the mixer. Provisions shall be made for obtaining representative samples of the aggregate.

C2 Placement and Hauling Equipment

All equipment furnished by the Contractor shall be well maintained and in a sound mechanical condition capable of doing the work. All equipment shall be serviced away from the paving site to prevent contamination of the mixture. Units that drip fuel, oil, or grease shall be removed from the mat until such leakage is corrected.

Lugs, lug treads, or spikes that affect the smoothness of the finished surface will not be permitted on any equipment.

C2a Bituminous Pavers

2331.3

Bituminous pavers shall be self-contained, power-propelled units, capable of spreading and finishing courses of bituminous plant mix material in widths applicable to the specified typical sections and thicknesses indicated in the Contract. The pavers shall be provided with either:

- (1) An activated screed, operated whenever the paver is in forward movement, or
- (2) A strike-off assembly, heated if necessary.

The paver 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. A windrow loader attachment may be used if approved by the Engineer.

The screed or strike-off assembly shall produce a finished surface of the required evenness and texture without tearing, shoving, or gouging. For mainline paving, screed extensions are required if the paving width on either side of the paver is greater than the basic screed unless otherwise directed by the Engineer. Strike-off only extension assemblies are not allowed for mainline wearing course paving, unless directed by the Engineer. Auger use shall be controlled by working gates at the back of the paver hopper.

All pavers shall be equipped with an approved automatic screed control. The automatic controls shall include a system of sensor-operated devices which follow reference lines or surfaces on one or both sides of the paver as required. At each end, the proper screed elevation shall be maintained by controlling the elevation of one end and automatically controlling the transverse slope or by controlling the elevation of each end independently.

Grade reference shall be achieved by an erected string line, a grade leveling ski or traveling string line, or a short reference shoe. The manner of use of the automatic slope control and grade reference devices will be determined by the Engineer, subject to the following requirements:

- (1) An erected string line control shall consist of a tightly stretched wire or string, offset from and parallel to the pavement edge on one or both sides, and set parallel to the established grade for the pavement surface. This control reference shall be set by the Contractor when required. The line shall be supported at intervals necessary to maintain the established grade and alignment. The control line shall be set sufficiently in advance of paving to avoid delays.
- (2) Grade leveling ski control shall consist of a manufacturer approved ski-type attachment or traveling string line, not less than 10 m (30 feet) in length, attached to the paver, and operating parallel to its line of travel.

2331.3

- (3) Short reference shoe control shall consist of a short shoe or joint matching device attached to the paver for reference control in matching existing surface grades at joints.

Automatic screed control by means of the erected string line shall only be required when stated in the Contract.

All mixtures shall be spread without segregation to the cross sections shown in the plans.

In general, leveling course mixtures shall be spread by the method producing the best results as approved by the Engineer. The objective is to secure a smooth base of uniform grade and cross section so that subsequent courses will be uniform in thickness. The leveling course mixture may be spread with a properly equipped paver or with a motor grader equipped with a leveling device, or with other means for controlling the surface elevation of the leveling course.

All base, binder, wearing, and shoulder wearing course mixtures shall be spread, to the fullest extent practicable, by a bituminous paver. Such mixtures may be spread by a motor grader only on areas that are inaccessible to a paver or on driveway entrances and on irregular areas where the quantity of mixture makes it impractical to place with a paver.

On shoulder surfacing and uniform width widenings, when the placement width is too narrow for a paver, the mixture in each course shall be spread with an approved mechanical device.

The speed of the paver shall be adjusted to produce the best results. The paving speed shall be coordinated with the rate of delivery of mixture to the paver to provide a uniform rate of placement without intermittent operation of the paver.

The placement of each course shall be completed over the full width of the section under construction on each day's run unless otherwise directed by the Engineer.

The contact surfaces of all fixed structures and the edge of the in-place mixture in all courses at transverse joints and in the wearing course at longitudinal joints shall be given a uniform but not excessive coating of liquid asphalt or emulsified asphalt before placing the adjoining mixture.

C2b Trucks

Trucks for hauling bituminous mixtures shall have tight, clean, and smooth beds. Mixture shall not be allowed to adhere to the truck beds. Adherence may be prevented by spraying the truck bed with an anti-adhesive agent that is on the approved list on file with the Bituminous Engineer. Each truck shall be equipped with a cover of canvas or other suitable material that extends at least 300 mm (**1 foot**) over the sides and attached to tie-downs to protect the mixture from the weather. The cover shall be used when required by the Engineer.

C2c Motor Graders

Motor graders shall be self-propelled and have pneumatic-tires with a tread depth of 13 mm ($\frac{1}{2}$ inch) or less. They shall be equipped with a blade not less than 3 m (**10 feet**) in length and shall have a wheel base of not less than 4.5 m (**15 feet**).

D Treatment of the Surface

D1 Tack Coat

A bituminous tack coat shall be applied to existing bituminous and concrete surfaces, and to the surface of each course or lift constructed, except for the final course or lift, according to 2357.

E Mixture Proportions

E1 Bituminous Material

The percentage of asphalt cement, by mass of the total mixture, shall be the quantity designated by the Bituminous Engineer. No working range is allowed. The spot check method, described in the Mn/DOT Bituminous Manual, shall be used to monitor and control the quantity of asphalt incorporated into the bituminous mixture during the mixture production.

On individual spot checks, the percentage of asphalt cement shall be within a tolerance of plus or minus 0.3 percentage points of the quantity designated and shall not fall below the minimum asphalt content by more than 0.1 percentage points.

Final asphalt cement content compliance may be determined based on beginning and end-of-day tank readings after deducting the quantity used and wasted.

Unless otherwise stated, the bitumen content of mixtures for median surfacing and other special purposes shall be the same as specified for shoulder course mixture.

E2 Job Mix Formula (JMF)

A job mix formula (JMF) is the composite gradation and asphalt content of the mixture.

No paving is allowed without a Department paving recommendation, except for small quantities (2331.3E2d) and for mixtures measured by the square meter per mm (**square yard per inch**) thickness (2331.3N). The Department will provide or verify two mix designs per type of mix, per Contract at no cost to the Contractor. Additional mix designs will be provided or verified at a cost of \$500 per design, payable to the Commissioner of Transportation.

For city, county, and other agency Projects that do not have federal or state-aid funding, the Contractor shall provide to the Materials Laboratory a complete Project proposal including addenda, supplemental agreements, change orders, and any Plan sheets (including typical sections) that affect the mix design. The Department will

2331.3

quality testing for each source, class, type, and size of virgin and neither start the mix design nor the verification process without this information.

Only with special arrangements will the Bituminous Engineer or the Materials Laboratory issue or verify non-standard mix designs, such as modifications to 2331, 2340/Certified Plant, or 3139 for city, county, and other agency Projects that do not have federal or state aid funding.

The bituminous mix may be designed using either Department 2331.3E2a or Contractor 2331.3E2b trial mix designs.

All test procedures and required forms are on file with the Bituminous Engineer.

E2aMn/DOT Trial Mix Design

- (1) At least 15 calendar days prior to the start of bituminous production, the Contractor shall submit to the Bituminous Engineer or the District Materials Engineer a 35 kg (**75 pounds**) sample of representative aggregate retained on the 4.75 mm (# 4) sieve and a 1.5 kg (**3 pounds**) sample that passes the 4.75-mm (# 4) sieve for non-asphaltic salvaged aggregate source used in the mix design.

Aggregates that require the magnesium sulfate soundness test shall be submitted to the Bituminous Engineer at least 30 calendar days prior to the start of bituminous production.

- (2) At least 15 calendar days prior to the start of bituminous mixture production, the Contractor shall submit, to the Bituminous Engineer, representative aggregate samples of each of the respective materials proposed for use in mix production. The submittal shall consist of approximately 135 kg (**300 pounds**) of aggregate material. If multiple aggregate sources or types are proposed, the 135 kg (**300 pounds**) may be proportioned to reflect the proposed blend (50 kg (**110 pounds**) minimum from any one source or type). The aggregate samples shall be obtained from representative aggregate. At the time of the aggregate(s) submittal, it is recommended that the Contractor also submit representative aggregate gradations for each of the different type of materials intended for use. The Contractor shall also indicate the proposed proportions of the aggregates to be incorporated into the mixture.
- (3) Using the representative aggregate samples submitted by the Contractor and the proposed mixture proportions; tests will be conducted to evaluate the acceptability of the proposed proportion to be used in the production of the bituminous mixture. Mixture evaluation will be based on the trial mix tests and the corresponding requirements listed in Table 2331-1A.

E2b Contractor Trial Mix Design

- (1) The requirements of 2331.3E2a(1) shall apply for this sample.

2331.3

- (2) At least 5 working days (7 working days for mixtures containing salvaged asphaltic material) prior to the start of bituminous mixture production, the Contractor shall submit in writing a proposed JMF for each combination of aggregates to the Bituminous Engineer for review and approval. The optimum percentage of bituminous material shall be that percentage which yields the design intent air voids and meets the other requirements of the Specification. For each JMF submitted, the Contractor shall include test data to demonstrate that mixtures conforming to each proposed JMF will have properties as specified. The proposed JMF shall be submitted on forms approved by the Department. In addition, the Contractor shall submit a 15 kg (**35 pounds**) uncompacted sample plus three Marshall briquettes compacted at the optimum asphalt content and Marshall design blows conforming to the JMF for laboratory examination and evaluation.

For mix designs that are produced from a Contractor Certified Plant, the optimum percentage of bituminous material shall be at least 0.2 percent above the minimum added new asphalt percentage limits as defined in Table 2331-1A.

- (3) The test data and the proposed JMF submitted by the Contractor for the Department's review and approval shall include for each blend:
- (a) The percentage (in units of 1 percent except 75 μm (**#200**) sieve in units of 0.1 percent) of aggregate passing each of the specified sieves for each aggregate (including the 850 μm (**#20**) and 180 μm (**#80**) sieves) to be incorporated into the mixture. The gradation of aggregate from salvaged asphaltic material shall be derived from the material after the residual asphalt has been extracted.
 - (b) The proportion of each material (in percent of total aggregate). A minimum of 5 percent of any aggregate is required.
 - (c) The composite gradation based on (a) and (b) above.
Note: Also include virgin composite gradation base on (a) and (b) above for mixtures containing recycled asphaltic pavement.
 - (d) The composite gradation plotted on FHWA 0.45 power graph paper. (Federal Form PR-1115)
 - (e) For mixtures containing salvaged asphaltic aggregate:
 - (i) The extracted asphalt content of the salvaged asphaltic aggregate with no retention factor included.
 - (ii) The extracted asphalt content of the total recycled mixture.

2331.3

- (f) The percentage (in units of 0.1 percent) of bituminous material to be added, based upon the total mass of the mixture.
- (g) A mix design with a minimum of three different asphalt contents (minimum 0.4 percent between each point), with at least one point above and one point below the optimum asphalt percentage, that reports the following (the Mn/DOT Bituminous Manual 5-693-435):

Note: When a nuclear asphalt content gauge is used to measure percent asphalt content in a bituminous mixture, a mix design with a minimum of four different asphalt contents (as stated above) is required. Four different asphalt contents are necessary to facilitate calibration of the gauge.

- (i) The maximum specific gravity (average of 2 tests) at each bitumen content. The theoretical maximum specific gravity used for percent air voids determination shall be calculated based on the average effective specific gravity determined from the average of two maximum specific gravity tests calculated at each asphalt content.
 - (ii) The Marshall test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimens at each bitumen content.
 - (iii) The percent of air voids in the mixture for each bitumen content.
 - (iv) The percent Voids in Mineral Aggregate (VMA) at each bitumen content.
 - (v) The Fines to Asphalt (F/A) ratio calculated to the nearest 0.1 percent.
- (h) Optional Add-Rock/Add-Sand Provisions: If the Contractor wants to use the add-material option to augment the submitted JMF, the Contractor shall provide samples of the aggregate for quality analysis in accordance with 2331.3E2b(1).

The Contractor shall provide mix design data for two additional Marshall design points per add-material. One point shall show a proportional adjustment to the submitted JMF that includes 5 percent, by mass, add-material at the JMF optimum asphalt percent. The second point shall show a proportional adjustment to the submitted JMF that includes 10 percent, by mass, add-material at the JMF optimum asphalt percent.

2331.3

The following information will be reported for each of these two points:

- (i) The maximum specific gravity (average of two tests).
- (ii) The Marshall test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimen at the optimum bitumen content.
- (iii) The percent air voids in the mixture for each point.
- (iv) The Fines to Asphalt (F/A) ratio calculated to the nearest 0.1 of a percent.

Up to two add-materials will be allowed per mix design submittal. Aggregate quality and mix characteristics are required for each proposed add-material and shall be submitted at the time of the original trial mix submittal. No mixture sample or Marshall briquettes are required for these two additional points.

E2c Mixture Designations

E2c(1) Mixture Design Requirements

Mixture evaluation will be based on the trial mix tests and the corresponding requirements listed in Table 2331-1A.

E2c(2) Certified Plant Mixture Designations

The certified plant mixture shall be designated according to Table 2331-1B.

(Table 2331-1A and Table 2331-1B on Succeeding Pages)

2331.3

**TABLE 2331-1A
MIXTURE DESIGN REQUIREMENTS**

| (A) Mixture Type | Compacted Lift Thickness | (B) Spec. 3139 Aggr. Size | (C) Marshall Stability Newtons (pounds) | Air Voids in Mixture (%) | (D) Hammer Blows Per Side | (E) Minimum Added New Asphalt Percentage Limits |
|----------------------------------|--|------------------------------------|---|-----------------------------------|------------------------------------|--|
| 31 & 32 (Wear) | Less Than 40 mm (1.5 inch) | A | 3350 - 13 350 (750 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.8 (31 Mix) 3.0 (32 Mix) |
| 31 & 32 (Wear) | 40 mm (1.5 inch) | A | 3350 - 13 350 (750 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.8 (31 Mix) 3.0 (32 Mix) |
| 31 & 32 (Wear) | 40 mm (1.5 inch) or Greater | B | 3350 - 13 350 (750 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.5 (31 Mix) 3.0 (32 Mix) |
| 31 & 32 (Non-Wear) | 25 mm (1.0 inch) or Less (F) | A | 3350 - 13 350 (750 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.0 (31 Mix) 2.8 (32 Mix) |
| 31 & 32 (Non-Wear) | Greater Than 25 mm (1.0 inch) | A & B | 3350 - 13 350 (750 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.0 (31 Mix) 2.8 (32 Mix) |
| 31 & 32 Base Only | 75 mm (3.0 inch) or Greater | A, B, & C | 3350 - 13 350 (750 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.0 (31 Mix) 2.8 (32 Mix) |
| 41, 42, 47 & 48 Wear | All | A | 4450 - 13 350 (1000 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.8 (41 & 47 Mix) 3.0 (42 & 48 Mix) |
| 41, 42, 47 & 48 Wear | (G) | B | 4450 - 13 350 (1000 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.5 (41 & 47 Mix) 3.0 (42 & 48 Mix) |
| 41, 42, 47 & 48 (Non-Wear) | Greater Than 25 mm (1.0 inch) | A & B | 4450 - 13 350 (1000 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.2 (41 & 47 Mix) 3.0 (42 & 48 Mix) |
| 41, 42, 47 & 48 (Non-Wear) | 25 mm (1.0 inch) or Less (F) | A | 4450 - 13 350 (1000 - 3000) | 3.0-5.0 4.0 (D) | 50 | 5.2 (41 & 47 Mix) 3.0 (42 & 48 Mix) |
| 61 Wear | All | CS | 4450 - 13 350 (1000 - 3000) | 3.0-5.0 4.0 (D) | 75 | 5.8 |
| 61 Wear | All | Blend of CS, SS, and/or TT | 4450 - 13 350 (1000 - 3000) | 3.0-5.0 4.0 (D) | 75 | 5.8 |
| 61 Wear | All | TT | 4450 - 13 350 (1000 - 3000) | 4.0+ | 75 | 7.5 |
| 61 (Non-Wear) | All | TT | 4450 - 13 350 (1000 - 3000) | 4.0+ | 75 | 7.5 |
| 61 (Non-Wear) | All | CS or Blend of CS and TT | 4450 - 13 350 (1000 - 3000) | 3.0-5.0 4.0 (D) | 75 | 5.5 |

2331.3

- NOTE: For mix design purposes, the total asphalt content in recycled mixtures containing salvaged asphaltic pavement shall be based on the extracted percent asphalt content (average of three tests) of the salvaged asphaltic aggregate (without retention factor), multiplied by the percent of salvaged asphaltic aggregate plus the percent new asphalt added to the total recycled mixture. In addition to complying with the minimums for added new asphalt, Types 32, 42, and 48 mixtures shall comply with the minimum requirements for Types 31, 41, and 47 mixtures, respectively, on a total asphalt basis (salvaged plus added).
- (A) The term "Wear" applies to wearing and shoulder wearing courses. The term "Non-Wear" applies to base, binder and leveling courses.
 - (B) Where more than one Type of mix is indicated, the size is the Contractor's option unless otherwise specified.
 - (C) Marshall stability and Marshall hammer blows shall comply with the given values. Values shall be adjusted based on traffic loadings as stated in the Special Provisions.
 - (D) To the extent permitted by these Specifications, the Department intends to design and maintain all mixtures at the indicated percentage air voids.
 - (E) All asphalt contents are based on the total mass of the mixture for new added asphalt.
 - (F) Includes designed course/lifts identified as 25 mm (**1 inch**) minimum.
 - (G) The use of Type 41 or 47 Mixtures (wear and shoulder wear) with aggregate Size B will only be allowed when specifically required in the Contract.

2331.3

TABLE 2331-1B
CERTIFIED PLANT MIXTURE DESIGNATIONS

| Mix Designation | Type | Course | Aggregate Size | Hammer Blows Per Side | Percent Crushing | AC Performance Grade |
|-----------------|------|--------|----------------|-----------------------|------------------|----------------------|
| 61WEA75100 | 61 | WE | A | 75 | 100 | See Note |
| 61BIB75100 | 61 | BI | B | 75 | 100 | See Note |
| 61LVB75100 | 61 | LV | B | 75 | 100 | See Note |
| 47WEA50070 | 47 | WE | A | 50 | 70 | See Note |
| 48WEA50070 | 48 | WE | A | 50 | 70 | See Note |
| 47BIA50070 | 47 | BI | A | 50 | 70 | See Note |
| 47LVA50070 | 47 | LV | A | 50 | 70 | See Note |
| 48BIA50070 | 48 | BI | A | 50 | 70 | See Note |
| 48LVA50070 | 48 | LV | A | 50 | 70 | See Note |
| 47BIB50070 | 47 | BI | B | 50 | 70 | See Note |
| 47LVB50070 | 47 | LV | B | 50 | 70 | See Note |
| 48BIB50070 | 48 | BI | B | 50 | 70 | See Note |
| 48LVB50070 | 48 | LV | B | 50 | 70 | See Note |
| 41WEA50055 | 41 | WE | A | 50 | 55 | See Note |
| 42WEA50055 | 42 | WE | A | 50 | 55 | See Note |
| 41BBA50055 | 41 | BB | A | 50 | 55 | See Note |
| 41BIA50055 | 41 | BI | A | 50 | 55 | See Note |
| 41LVA50055 | 41 | LV | A | 50 | 55 | See Note |
| 42BBA50055 | 42 | BB | A | 50 | 55 | See Note |
| 42BIA50055 | 42 | BI | A | 50 | 55 | See Note |
| 42LVA50055 | 42 | LV | A | 50 | 55 | See Note |
| 41BBB50055 | 41 | BB | B | 50 | 55 | See Note |
| 41BIB 50055 | 41 | BI | B | 50 | 55 | See Note |
| 41LVB50055 | 41 | LV | B | 50 | 55 | See Note |
| 42BBB50055 | 42 | BB | B | 50 | 55 | See Note |
| 42BIB50055 | 42 | BI | B | 50 | 55 | See Note |
| 42LVB50055 | 42 | LV | B | 50 | 55 | See Note |
| 31WEA50000 | 31 | WE | A | 50 | 0 | See Note |
| 31WEB50000 | 31 | WE | B | 50 | 0 | See Note |
| 31SHA50000 | 31 | SH | A | 50 | 0 | See Note |
| 31SHB50000 | 31 | SH | B | 50 | 0 | See Note |
| 32WEA50000 | 32 | WE | A | 50 | 0 | See Note |
| 32WEB50000 | 32 | WE | B | 50 | 0 | See Note |
| 32SHA50000 | 32 | SH | A | 50 | 0 | See Note |
| 32SHB50000 | 32 | SH | B | 50 | 0 | See Note |
| 31BBA50000 | 31 | BB | A | 50 | 0 | See Note |
| 31BIA50000 | 31 | BI | A | 50 | 0 | See Note |
| 31LVA50000 | 31 | LV | A | 50 | 0 | See Note |
| 31BBB50000 | 31 | BB | B | 50 | 0 | See Note |

| Mix Designation | Type | Course | Aggregate Size | Hammer Blows Per Side | Percent Crushing | AC Performance Grade |
|-----------------|------|--------|----------------|-----------------------|------------------|----------------------|
| 31BIB50000 | 31 | BI | B | 50 | 0 | See Note |
| 31LVB50000 | 31 | LV | B | 50 | 0 | See Note |
| 32BBA50000 | 32 | BB | A | 50 | 0 | See Note |
| 32BIA50000 | 32 | BI | A | 50 | 0 | See Note |
| 32LVA50000 | 32 | LV | A | 50 | 0 | See Note |
| 32BBB50000 | 32 | BB | B | 50 | 0 | See Note |
| 32BIB50000 | 32 | BI | B | 50 | 0 | See Note |
| 32LVB50000 | 32 | LV | B | 50 | 0 | See Note |
| 31BBC50000 | 31 | BB | C | 50 | 0 | See Note |
| 32BBC50000 | 32 | BB | C | 50 | 0 | See Note |

*Note: An additional letter is added to the above mix designations to identify AC Performance Grade:

Performance Grade Letter Designation

- A PG 52-34
- B PG 58-28
- C PG 58-34
- D PG 58-40
- E PG 64-28
- F PG 64-34
- G PG 64-40
- H PG 70-28
- I PG 70-34
- L PG 64-22

Course Abbreviations

- WE Wearing Course
- BI Binder Course
- BB Base Course
- SH Shoulder Course
- LV Leveling Course

The Contractor shall:

- (1) Have only one type of each mix designation in effect at any given time.
- (2) Record mixtures that have asphalt binders with different performance grades on the same control charts if all other mixture designation information is identical. (2340/Certified Plant)
- (3) Plot data on mixtures representing various courses (WE, LV, BI, BB, Etc.) on the same control chart when the mixture requirements are the same. (2340/Certified Plant)

2331.3

E2d Mixture Production

- (1) Except for small quantities (Form 2415) as defined in the Schedule for Materials Control, no bituminous mixture shall be placed without an approved mix design issued to the specific Project for that specific course by the Bituminous Engineer.
- (2) The requirements for mixture production proportions shall comply with 2331.3E; except that the JMF percentages and permissible working range will be established based on the composite aggregate gradation (including extracted asphaltic aggregate) and asphalt content of the approved mix design. The working range for individual tests (N=1) will be determined by applying plus and minus values to the percentages in the JMF in accordance with Table 2331-2.

**TABLE 2331-2
JMF WORKING RANGES**

Mix Characteristic

| <u>Gradation:</u> | <u>Working Range</u> |
|--|-----------------------------|
| 4.75 mm (#4) sieve or greater..... | +/- 5% |
| 2.00 mm (#10) and 425 µm (#40) sieves..... | +/- 4% |
| 75 µm (#200) sieve..... | +/- 2% |
| Bitumen Content | None |

- (3) The JMF shall remain in effect until changed in writing. Should an aggregate source change, or when unsatisfactory results or other conditions make it necessary, a new JMF may be required.
- (4) In accordance with 1503, the aggregate materials shall be uniform in character and shall conform as nearly as possible to the middle portion of the working range to ensure that the mixture meets the mix design criteria.
- (5) Aggregate and bituminous mixture samples may be taken at any time during mixture production and placement to verify compliance with the aggregate and design requirements previously established. If the sample is not in compliance, a new mix design or an adjustment in the JMF will be required.

E2e Recycled Mixture Requirements

- (1) If the Contractor produces recycled bituminous mixture(s) (Type 32, 42, or 48), the mixture(s) shall consist of a combination of any of the following: virgin aggregate, salvaged aggregate or crushed concrete, and salvaged asphaltic material. Recycled bituminous material (Type 32) produced in accordance with the provisions herein may be substituted for all Type 31 mixtures. Recycled bituminous mixtures (Type 42) produced in accordance

2331.3

with the provisions herein may be substituted for all Type 41 mixtures. Recycled bituminous mixtures (Type 48) produced in accordance with the provisions herein may be substituted for all Type 47 mixtures. For documentation purposes, recycled mixtures shall be identified as Type 32, 42, or 48 mixtures.

- (2) The minimum total asphalt content, minimum new asphalt content, and the extracted gradation requirements shall be verified based upon production sampling and testing.
- (3) Salvaged materials (salvaged aggregates, crushed concrete, or salvaged asphaltic pavement) containing any objectionable material, i.e., road tar, metal, glass, wood, plastic, brick, rubber, fabric, or any other material having similar characteristics will not be permitted for use in recycled bituminous mixture(s).
- (4) Salvaged materials may be incorporated into recycled mixtures in accordance with Table 2331-3.
- (5) Use the following criteria to find the asphalt binder performance grade to be used for HMA Mixtures with RAP.

| | > 20% RAP | < 20% RAP |
|------------------|---------------------|---------------------|
| Overlay | No grade adjustment | No grade adjustment |
| New Construction | No grade adjustment | See Table below |

New Construction >20% RAP

| Specified Asphalt Binder Grade | New Asphalt Binder Grade used with RAP |
|--------------------------------|--|
| PG 64-34 | >20% RAP Not Allowed |
| PG 58-34 | PG 52-34 |
| PG 64-28 | PG 64-28 |
| PG 58-28 | PG 52-34 |
| PG 52-24 | PG 52-34 |
| All other grades | Contact Department Bituminous Engineer |

The binder grade can also be selected by using the appropriate blending chart approved by the Bituminous Office if the mix designer chooses to adjust the binder selection to compensate for the stiffness of the reclaimed asphalt binder.

2331.3

- (6) Types 32, 42, and 48 virgin and non-asphaltic salvaged aggregate shall meet the quality and crushing requirements of 3139 for Types 31, 41, and 47 mixture aggregate, respectively.
- (7) All salvaged asphaltic pavement materials to be incorporated into Type 32 recycled mixture shall be sized so that no particle is greater than 75 mm (**3 inches**) in any dimension. The final recycled mixture loaded into transport vehicles at the plant shall have no particle exceeding the maximum aggregate size required under this Specification and 3139 for Type 31 mixtures.

**TABLE 2331-3
ALLOWABLE SALVAGED MATERIAL FOR RECYCLING
Maximum Percentage Permitted**

| Salvaged Material Type | Type 32 Mixtures | | |
|--|------------------|---------------|------|
| | Non Wear | Shoulder Wear | Wear |
| Salvaged Aggregate | 100 | 100 | 100 |
| Salvaged Asphaltic Pavement | 50 | 50 | 30 |
| Crushed Concrete | 50 | 0 | 0 |
| Salvaged Asphaltic Pavement and Crushed Concrete(combination thereof) ^(A) | 85 | 0 | 0 |
| Scrap Shingles ^(C) | 5 | 5 | 5 |
| Salvaged Asphaltic Pavement and Scrap Shingles ^(C) (combination thereof) ^(B) | 50 | 50 | 30 |

| Salvaged Material Type | Type 42 Mixtures | | |
|--|------------------|----------------|------|
| | Base | Binder & Level | Wear |
| Salvaged Aggregate | 100 | 100 | 100 |
| Salvaged Asphaltic Pavement | 50 | 30 | 30 |
| Crushed Concrete | 30 | 20 | 0 |
| Salvaged Asphaltic Pavement and Crushed Concrete (combination thereof) ^(A) | 50 | 30 | 0 |
| Scrap Shingles ^(C) | 5 | 5 | 5 |
| Salvaged Asphaltic Pavement and Scrap Shingles ^(C) (combination thereof) ^(B) | 50 | 30 | 30 |

(A) Neither component shall exceed 50 percent of the total aggregate by mass.
 (B) The scrap shingle component shall not exceed 5 percent
 (C) Scrap shingles allowed only when approved by the Engineer. Specifications on file with the Bituminous Engineer.

Maximum Percentage Permitted

| Salvaged Material Type | Type 48 Mixtures | | |
|-----------------------------|------------------|----------------|------|
| | Base | Binder & Level | Wear |
| Salvaged Aggregate | 100 | 100 | 100 |
| Salvaged Asphaltic Pavement | 50 | 30 | 30 |

- (8) All salvaged asphaltic pavement materials to be incorporated into Type 42 or 48 recycled mixtures shall be sized so that no particle is greater than 19 mm (**3/4 inch**) in any dimension. The final recycled mixture loaded into transport vehicles at the plant shall have no particle exceeding the maximum aggregate size required under this Specification and 3139 for Type 41 or 47 mixtures, respectively.
- (9) All salvaged aggregate shall be stockpiled uniformly to limit variation in mixture properties.

F Blank

G Blank

H Compaction Operations

The Contractor shall obtain compaction by the control strip method unless the specified density method or the ordinary compaction method are designated in the Contract.

After being spread, each course shall be compacted to the required density. While following the paver as close as possible without causing undue displacement, the initial course of any paver-laid mixture shall be compacted with a steel-wheeled tandem roller, steel three-wheeled roller, vibratory roller, or pneumatic-tired roller. A pneumatic-tired roller shall be available for compaction operations within 24 hours after request by the Engineer. The final rolling shall be performed with a tandem steel-wheeled roller. Areas that are inaccessible to the conventional type rolling equipment shall be compacted to the required density by using trench rollers or mechanical tampers.

In general, the rolling shall begin at the lower edge of the strip and progress toward the upper edge; however, when a longitudinal joint is formed by adjoining strips, the first pass of the roller shall be over that joint. Each pass of the roller shall terminate at least 1 m (**3 feet**) in advance of or to the rear of the termination of the previous pass. The final rolling shall be continued until all roller marks are eliminated.

2331.3

When mixtures are spread by a motor grader, the use of a steel-wheeled roller for the initial rolling will not be permitted. The pneumatic-tired rolling shall compact the mixture simultaneously with the spreading operation.

The rollers shall, as practicable, be operated continuously so all areas are thoroughly compacted to the required density. When not operating, the rollers shall not stand on the uncompacted mixture or newly rolled pavement having a surface temperature exceeding 60°C (140° F). Rolling with steel-wheeled rollers shall be discontinued if it produces excessive crushing or pulverizing of the aggregate or displacement of the mixture.

To prevent adhesion of the mixture to the roller wheels, the contact surfaces of the wheels shall be kept properly moistened using water or a water solution containing small quantities of a detergent or other approved material.

To secure a true surface, variations such as depressions or high areas, which may develop during rolling operations, and lean, fat or segregated areas shall be corrected by removing and replacing the material in the defective area. All such corrections shall be accomplished as directed by the Engineer at no expense to the Department.

The Engineer may specify or modify in writing (with concurrence from the Bituminous Engineer) a minimum laydown temperature, and specify additional rollers or roller type, when the roadbed, placement, mixture, or equipment conditions warrant change.

H1 Control Strip Method

The control strip method of compaction shall consist of the construction of control strips and the determination of paving course density requirements and compliance, in accordance with the following:

H1a Construction

A control strip shall be constructed at the beginning of work on each lift of each course. Each control strip shall have an area of at least 330 m² (**400 square yards**) and shall have the same thickness as the lift it represents. It shall be constructed on a subgrade or pavement approved by the Engineer. The control strips shall remain in place and become part of the completed work.

The materials used in the construction of control strips shall conform to the specified requirements for the course. The materials used in each control strip shall be from the same source and of the same type as the materials used in the remainder of the course that the control strip represents.

2331.3

The equipment used in the construction of the control strips shall be approved by the Engineer and shall be the same type and mass used on the remainder of the pavement course represented by the control strip. The rollers shall be as specified in 2331.3H3. A rolling pattern shall be established for each roller.

Construction of control strips shall be directed by the Engineer. Compaction shall commence as soon as possible after the mixture has been spread to the desired thickness and shall continue until no appreciable increase in density can be obtained by additional roller coverages. Densities will be determined by a portable nuclear testing device, furnished and operated by the Contractor. The device shall be calibrated according to procedures described in the Mn/DOT Bituminous Manual. The Contractor shall give the Department the opportunity to monitor all tests and shall provide the required completed documentation to the Department. Before the Engineer's approval is given, the Department must have monitored the tests and signed the documentation.

The Engineer will order a new control strip when:

- (1) Any change in the JMF is made, or
- (2) A change in the source of material is made or a change in the material from the same source is observed.

The Engineer may order or the Contractor may request a new control strip when:

- (1) Ten days of production have been accepted without construction of a new control strip, or
- (2) There are other reasons to believe that a control strip density is not representative of the bituminous mixture being placed.

H1b Determination of Project Density

Upon completion of the rolling, the mean density of the control strip will be determined by averaging the results of 10 nuclear density tests taken at randomly selected sites within the control strip. The mean density of the control strip shall be the target density for the remainder of the pavement course it represents.

If the mean density of the control strip determined above is less than 96 percent of the density of a specimen of the bituminous mixture compacted by the Marshall compaction method as described in the Mn/DOT Bituminous Manual, the Engineer will order the construction of a new control strip.

H1c Density Compliance and Acceptance

Acceptance will normally be made in lots equal to the number of metric tons (**tons**) of mixture placed in each lift on each production day. Each lot will be divided into five sublots of approximately equal surface area. If 1-day's production from any course is less than 500 metric tons

2331.3

(500 tons) , it may be combined with the next day's production of that lift to form a lot. One density determination will be made with a portable nuclear testing device at randomly selected test sites within each subplot.

The relative density of each test site will be determined by dividing the density at the site by the appropriate mean control strip density and multiplying by 100. The mean and the range of the relative densities at the five sublots in each lot will be determined and inserted in the following equation to determine the Quality Level of each lot:

$$\text{Quality Level} = \text{Mean Relative Density} - (.60 \times \text{Range})$$

If the Quality Level of any lot is found to be less than 95.5, payment for the bituminous mixture in that lot will be reduced to a percentage of the Contract bid prices shown in Table 2331-4:

**TABLE 2331-4
PAY FACTORS FOR CONTROL STRIP METHOD DENSITY**

| <u>Quality Level</u> | <u>Pay Factor</u> (% of Contract Price) <u>All Mixtures</u> |
|------------------------|---|
| 95.5 or higher | 100% |
| 94.5 to 95.4 incl..... | 97.5% |
| 93.5 to 94.4 incl..... | 95% |
| 92.5 to 93.4 incl..... | 90% |
| 91.5 to 92.4 incl..... | 80% |
| 91.4 or lower | Disposition of lot to be determined by the Engineer |

H2 Specified Density Method

If the specified density method of compaction is required, each lift shall be uniformly compacted to a density not less than 95 percent of the Marshall density. The Marshall density test shall be according to the procedure described in the Mn/DOT Bituminous Manual.

Cores shall not be taken within 0.3 m (**1 foot**) of a longitudinal joint or edge nor within 6 m (**20 feet**) of a transverse joint.

For the specified density method of compaction, determination of the density obtained in the compacted mixture will be made by the Engineer on samples taken by the Contractor from each lift placed. Samples shall be taken from each day's production at the direction of the Engineer, prior to placement of the next course and not later than the next working day following the date of placement. Sampling

2331.3

shall be at the rate of not less than one sample per 1000 metric tons (**1000 tons**) or fraction thereof placed in each course. The Contractor may be required to chill the compacted mixture before coring the samples so that the samples may be removed intact without distortion. The samples shall be cut using a 100 to 155 mm (**4 to 6 inches**) diameter maximum coring device. All samples shall be taken and delivered by the Contractor, under the supervision of the Engineer, to the Department's field laboratory. Immediately after taking the cores, sampling holes shall be refilled with the same type of material and properly compacted. All operations incidental to sampling shall be done at no expense to the Department.

The mixture with failing density will not be accepted for payment at the Contract bid price, but, in lieu of being removed and replaced, will be accepted at a reduced price in accordance with Table 2331-5. The appropriate pay factor will be applied to the quantity of mixture represented by the failing density test. One retest of each failing test will be permitted and the higher of the two densities will be used in determining the pay factor. All retesting shall be done within 3 working days after placement of the bituminous mixture.

**TABLE 2331-5
PAY FACTORS FOR SPECIFIED DENSITY**

| Field Density (% of Marshall Density) | Pay Factor (% of Contract Price) |
|--|---|
| 95.0 or Higher | 100% |
| 94.0 to 94.9 | 99% |
| 93.0 to 93.9 | 97.5% |
| 92.0 to 92.9 | 95% |
| 91.0 to 91.9 | 92.5% |
| 90.0 to 90.9 | 87.5% |
| Less than 90.0 | Remove and Replace |

H3 Ordinary Compaction Method

A control strip shall be used to establish a rolling pattern, which shall be used by the Contractor for the compaction of the asphalt mixture for the layer on which the control strip is constructed, or until a new control strip is constructed. The control strip requirement may be waived by the Engineer in small localized areas or other areas not conducive to its establishment.

A control strip shall be constructed at the beginning of the work on each lift of each course. Each control strip shall have an area of at least

2331.3

330 m² (**400 square yards**) and shall be of the same thickness as the lift it represents. The subgrade or pavement course upon which a control strip is to be constructed shall have the prior approval of the Engineer. The control strips shall remain in place and become part of the completed work.

The materials used in the construction of the control strips shall conform to the specified requirements for the course. The materials used in the control strip shall be from the same source and of the same type as the materials used in the remainder of the course that the control strip represents.

The equipment used in the construction of the control strips shall be approved by the Engineer and shall be the same type and mass used on the remainder of the pavement course represented by the control strip. A minimum of two rollers shall be required. A rolling pattern shall be established for each roller.

Construction of the control strips will be as directed by the Engineer. Compaction shall commence as soon as possible after the mixture has been spread to the desired thickness and shall continue until no appreciable increase in density can be obtained by additional rollers coverages. Densities will be determined by means of a portable nuclear testing device.

To determine when no appreciable increase in density can be obtained, two test points shall be established in the control strip on a random basis and the density at each point shall be measured by a portable nuclear device after each roller pass. Rolling shall be suspended when testing shows either:

- (a) A decline in density with additional roller passes, or
- (b) When no increase in density is obtained by an additional roller pass.

Rolling shall be discontinued when surface cracking or checking occurs behind the roller.

After said testing is accomplished, rolling on the remainder of that course shall be done in accordance with the pattern developed in the test strip for that roller. A separate rolling pattern and time interval shall be established for each roller.

A new control strip shall be ordered by the Engineer when:

- (a) A change in the JMF is made, or
- (b) A change in the source of material is made or a change in the material from the same source is observed.

A new control strip may be ordered by the Engineer or requested by the Contractor when:

- (a) Ten days of production have been accepted without construction of a new control strip, or

2331.3

- (b) There are other reasons to believe that a control strip density is not representative of the bituminous mixture being placed.

The nuclear testing device shall be furnished and operated by the Contractor. The furnishing of the nuclear testing device and the operator will be considered incidental to the furnishing and placement of the bituminous mixture and shall not be compensated for separately. The device shall be calibrated according to procedures described in the Mn/DOT Bituminous Manual.

Each course shall be uniformly compacted until there is no further evidence of consolidation and all roller marks are eliminated. When this method is employed, and the quantity of mixture placed by the paver exceeds 90 metric tons (**100 tons**) per hour least two rollers are required for compacting the mixture placed by each paver.

H3a Rollers

The following requirements for rollers apply only when compaction is obtained by the ordinary compaction method.

H3a(1) Steel-Wheeled Rollers

Steel-wheeled rollers shall be self-propelled and have a minimum total mass of 7.3 metric tons (**8 tons**), or as otherwise specified in the Contract. When vibratory rollers are used, they shall produce 45 kN per meter (**250 pounds per inch**) of width. The roller shall be capable of reversing without backlash and shall be equipped with spray attachments for moistening all rollers on both sets of wheels.

H3a(2) Pneumatic-Tired Rollers

The pneumatic-tired roller shall have a compacting width of 1.5 m (**5 feet**) or more and shall be so constructed that the gross mass of not less than 3500 kg per meter (**200 pounds per inch**) of rolling width can be varied as directed by the Engineer. The tire arrangement shall be such that full compaction will be obtained over the full width with each pass of the roller.

The roller may be self propelled or provided with suitable tractive equipment, unless the Contract specifies a certain type. If more than one roller propelled by a single tractive unit, the combination will be counted as a single roller unit.

H3a(3) Trench Rollers

The trench roller shall be self propelled and have a mass of not less than 4400 kg per meter (**250 pounds per inch**) of width.

H3b Mixture Temperature Controls

If compaction is obtained by the ordinary compaction method, the minimum laydown temperature in all courses (as measured behind the paver or spreading machine) of the bituminous mixture shall be in accordance with the temperature requirements of Table 2331-6:

2331.3

**TABLE 2331-6
MIXTURE TEMPERATURE CONTROL**

| Air Temp. °C (° F) | Compacted Mat Thickness, mm (inches) ^(A) | | | |
|--------------------------|--|-----------------------------|---------------------|-----------------------------------|
| | 25 mm (1 inch) | 40 mm (1-1/2 inch) | 50 mm (2 inches) | 75 mm (3 inches) or Greater |
| | Required Laydown Temperature °C (° F) | | | |
| +0 - 4 (32- 40) | – | 129 ^(B) (264) | 124 (255) | 121 (250) |
| +5 - 10 (41-50) | 130 ^(B) (266) | 127 (261) | 121 (250) | 118 (244) |
| +11 - 15 (51-60) | 127 ^(B) (261) | 124 (255) | 118 (244) | 115 (239) |
| +16 - 21 (61-70) | 121 ^(B) (250) | 118 (244) | 115 (239) | 113 (235) |
| +22 - 27 (71-80) | 118 (244) | 115 (239) | 113 (235) | 113 (235) |
| +28 - 32 (81-90) | 113 (235) | 110 (230) | 110 (230) | 110 (230) |
| +33 (+91) | 110 (230) | 110 (230) | 110 (230) | 110 (230) |

(A) Based on approved or specified compacted lift thickness.

(B) A minimum of one pneumatic-tire roller shall be used for intermediate rolling unless otherwise directed by the Engineer.

I Blank

J Thickness and Surface Requirements

After compaction, the thickness of each course shall be within a tolerance of 13 mm (**1/2 inch**) (a tolerance of 6 mm (**1/4 inch**) for 25 mm (**1 inch**) wearing course mixtures) of the thickness shown in the Plans, except that, if automatic grade controls are used, this thickness requirement will not apply to the first course placed. This thickness requirement will not apply to the leveling course whether or not automatic grade controls are required. Any part of any course that is **I** constructed to less than the minimum required thickness may be removed and replaced at the discretion of the Engineer.

On that portion of any course constructed to more than the maximum permissible thickness, the materials used in the excess mixture above that required to construct that portion of the course to

2331.3

the Plan thickness plus 13 mm (**1/2 inch**) will be excluded from the pay quantities and may require removal and replacement at the discretion of the Engineer.

After compaction, the finished surface of each course shall be reasonably free of open and torn sections and shall be smooth and true to the grade and cross section shown on the Plans with the following tolerances:

- (1) Where a leveling course is specified, it shall be constructed to within a tolerance of 15 mm (**0.05 foot**) of the elevations and grades established by the Engineer. This requirement shall also apply to the first course placed other than leveling when automatic controls are used.
- (2) The surface of the binder course and wearing course shall show no variation greater than 3 mm (**1/8 inch**) from the edge of a 3 m (**10 foot**) straightedge laid parallel to or at right angles to the centerline. Shoulder surfacing and surfacing on temporary connections and by-passes shall show no variations greater than 6 mm (**1/4 inch**) from the edge of a 3 m (**10 foot**) straightedge laid parallel to the centerline.
- (3) The transverse slope of the surface of each course, exclusive of the shoulder wearing course, shall not vary from the slope shown in the Plans by more than 0.4 percent.
- (4) The distance between the edge of each course and the established centerline shall be no less than the Plan distance nor more than 75 mm (**3 inches**) greater than the Plan distance. In addition, the edge alignment of the wearing course on tangent sections and on curve sections of 3 degrees or less shall not deviate from the established alignment by more than 25 mm (**1 inch**) in any 7.5 m (**25 foot**) section. Any material placed outside the above described limitations shall be removed after being cut or sawed at no expense to the Department.

K Construction Joints

Joints shall be thoroughly compacted to produce a neat, tightly bonded joint that meets surface tolerances.

K1 Transverse Joints

A transverse joint (full paver width at right angles to the centerline) shall be constructed when mixture placement operations are suspended.

The forward end of the freshly laid strip shall be thoroughly compacted by rolling before the mixture has cooled. When work is resumed, the end shall be cut vertically for the full depth of the layer unless a formed edge is constructed as approved by the Engineer.

K2 Longitudinal Joints

Longitudinal joints between strips shall be parallel to the centerline.

2331.3

In multiple lift construction, the longitudinal joints between strips in each lift shall be constructed not less than 150 mm (**6 inches**) measured transversely from the longitudinal joints in the previously placed lift. When the wearing course is constructed in an even number of strips, one longitudinal joint shall be on the centerline of the road. When it is constructed in an odd number of strips, the centerline of one strip shall be on the centerline of the road, provided that no joint is located in the wheel path area of a traffic lane.

At longitudinal joints formed by placing multiple strips, the adjoining surface being laid shall, after final compacting, be slightly higher (but not to exceed 3 mm (1/8 inch)) than the previously placed strip.

When constructing a strip adjoining a previously placed strip or a concrete pavement, any fresh mixture that overlaps a previously placed strip or pavement shall be removed (to the longitudinal joint line) before any rolling is done.

After final compaction, all bituminous wearing course surfaces adjacent to concrete pavements shall be flush with the concrete surface, within a tolerance of 3 mm (**1/8 inch**).

After final compaction, all bituminous surfaces adjacent to gutters, manholes, pavement headers, or other fixed structures shall be slightly higher (but not to exceed 6 mm (**1/4 inch**)) than the surface of the structure.

L Blank

M Bituminous Mixture Production (FOB Department Trucks)

For bituminous mixture production, the Contractor shall, in addition to the bituminous mixture required on the Project, produce and deliver bituminous mixture to the Department. The mixture shall be the mixture being produced and shall be loaded on Department furnished trucks at the mixing plant at a time agreed on by the Engineer and Contractor. The Engineer will notify the Contractor of the total quantity of mixture desired not less than 2 weeks prior to completion of the wearing course construction. The Engineer will not accept the bituminous mixture if it is inappropriate for the Department's intended use.

N Bituminous Mixtures Measured by the Square Meter (Yard) per Specified mm (inch) Thickness

For bituminous mixture measured by the square meter (**yard**) per specified mm (**inch**) thickness, the Contractor shall certify in writing that the bituminous mixture delivered to the Project meets the appropriate requirements. An approved bituminous paving recommendation is not required; however, the mixture shall meet the

2331.3

requirements of Table 2331-1A. The Department will obtain samples, as determined by the Engineer, to verify percent air voids, compliance with minimum asphalt contents, gradation requirements of 3139, and make other tests deemed appropriate to verify compliance.

2331.4 METHOD OF MEASUREMENT

A Bituminous Mixture

Bituminous mixture of each type will be measured separately by mass, based on the total quantity of material hauled from the mixing plant, with no deductions being made for the bituminous materials.

B Bituminous Material

Bituminous material will be measured by mass of the material furnished and used in all mixtures, in accordance with 1901, to determine compliance with the asphalt content recommendations.

C Irregular Width Paving

Irregular width paving, as classified in the Contract, will be measured by area on the basis of actual surface dimensions placed, without regard to the mixture designation or the number of courses placed on each area.

D Bituminous Mixtures Measured by the

Square Meter (square yard) per Specified mm (inch) Thickness

Bituminous mixture of each type and for each specific course will be measured separately by area and by thickness on the basis of actual final dimensions placed.

2331.5 BASIS OF PAYMENT

Payment for the accepted quantities of bituminous mixture used in each course at the Contract prices per unit of material will be compensation in full for all costs of constructing the bituminous surfacing as specified, including the costs of furnishing and incorporating any asphalt cement, mineral filler, hydrated lime, or anti-stripping additives that may be permitted or required.

If the Marshall density at the recommended or established asphalt content is in excess of 2500 kg/m^3 (**160 pounds per cubic foot**), payment for mixture will be at 85 percent of the contracted unit price.

In the absence of appropriate Contract items covering shoulder surfacing and other special construction, the accepted quantities of material used for these purposes will be included for payment with the wearing course materials.

For mixtures containing salvaged material, payment will be the same as for virgin mixtures. Type 32 mixtures will be paid for as Type 31 mixtures, Type 42 mixtures will be paid for as Type 41 mixtures, and Type 48 mixtures will be paid for as Type 47 mixtures.

Payment for the item of bituminous mixture production at the Contract unit price of mixture produced will be compensation in full for

2331.5

all costs of producing the mixture and loading it on board the Department's trucks at the mixing plant. The provisions of 1903 are modified to the extent that the Department will not make a price adjustment in the event of increased or decreased quantities of bituminous mixture items.

Payment for irregular width paving at the Contract unit price of pavement surface area will be compensation in full for the costs of irregular width placement, regardless of mixture designation or the number of courses placed on each area so classified.

Payment for the plant mixed bituminous surface will be made on the basis of the following schedule:

| Item No. | Item | Unit |
|-----------------|--|-------------------------------------|
| 2331.508 | Type ___ Wearing Course Mixture | metric ton (ton) |
| 2331.510 | Type ___ Binder Course Mixture | metric ton (ton) |
| 2331.512 | Type ___ Leveling Course Mixture..... | metric ton (ton) |
| 2331.514 | Type ___ Base Course Mixture | metric ton (ton) |
| 2331.516 | Type ___ Shoulder Mixture..... | metric ton (ton) |
| 2331.518 | Type ___ Bituminous Mixture for Specified Purpose | metric ton (ton) |
| 2331.521 | Irregular Width Paving | square meter (square yard) |
| 2331.525 | Type ___ , ___ Course Mixture, mm thick..... | square meter (square yard) |
| 2331.549 | Type ___ Bituminous Mixture Production | metric ton (ton) |

NOTE: If either mineral filler or hydrated lime is required in any bituminous mixture item, the item name must be expanded by adding the words: (with Filler) or (with Lime).

2340
Plant Mixed Bituminous Pavement
Quality Control/Quality Assurance
(Type 31, 41, 47, 61)

2340.1 DESCRIPTION

This work shall consist of constructing one or more pavement courses of hot plant mixed bituminous aggregate mixture on a prepared surface for quality control/quality assurance (QC/QA) Projects.

A Quality Control (QC)

The Contractor shall demonstrate QC by doing testing during the construction process.

B Quality Assurance (QA)

The Department will do QA testing as part of the acceptance process. The Engineer is responsible for QA testing, records, and acceptance. The Engineer will accomplish the QA process by:

- (1) Conducting assurance (acceptance) testing of companion samples.
- (2) Observing tests performed by the QC personnel.
- (3) Monitoring the required QC summary sheets and control charts.
- (4) Directing the Contractor to take additional samples at any time and any location during production.

2340.2 MATERIALS..... 2331.2

2340.3 CONSTRUCTION REQUIREMENTS

The Contractor shall comply with the construction requirements in 2331.3, except as modified by the following:

A General

The Contractor shall comply with 2331.3A and the following:

A1 Contractor Certified Plant Bituminous Mixtures

When the Contract requires Contractor Certified Plant Bituminous Mixtures, the Contractor shall also comply with the following:

A1a Certification Procedure

The Contractor shall:

- (1) Complete application form and request for plant inspection.
- (2) Provide a site map of stockpile locations.
- (3) Pass plant and testing facility inspection by having the plant inspector and bituminous plant authorized agent complete and sign the Bituminous Plant Inspection Report (TP 02142-01, TP 02143-01). By signing the Bituminous Plant Inspection Report, the bituminous plant authorized agent agrees to calibrate and maintain all plant and laboratory equipment within allowable

2340.3

tolerances set forth in the Specifications and the Mn/DOT Bituminous Manual.

(4) Obtain approved mix design recommendations prior to production.

A1b Maintaining Certification

To maintain certification, the plant must produce, test, and document all certified plant bituminous mixtures in accordance with the above requirements on a continuous basis. Continuous basis means all bituminous mixtures supplied from a certified plant to any state agency project with 2340 bituminous mixtures must be sampled and tested in accordance with 2340 requirements. When mixtures are supplied to projects not specifying 2340 requirements for more than 3 working days the supplier shall either:

- (1) Begin testing at least 2 days before producing 2340 bituminous mixtures for a Project with 2340 requirements, or
- (2) Use the first-day sampling rate of four samples per day as stated in the Mn/DOT Sampling and Testing Program.

The Contractor shall assure the plant certification procedure is performed annually after winter suspension and before producing material for a Project with certified plant requirements. The Contractor shall recertify a plant when it is moved to a new location.

A1c Revocation of Plant Certification

The Mn/DOT Construction Engineer may revoke certification of an asphalt plant when requirements are not being met or records are falsified. The Department may revoke the Technician Certification for individual involved.

The Mn/DOT Bituminous Engineer and the Mn/DOT Contract Administrator will maintain a list of companies who have had their asphalt plant certification revoked.

A1d Sampling and Testing

The Contractor shall supply random numbers of QC samples. The Contractor shall submit the samples in containers approved by the Engineer.

The Contractor shall perform QC sampling and testing according to the Mn/DOT Materials Control Schedule for Bituminous Construction Items for Quality Assurance Projects (2340). However, for the percentage of crushing of aggregates the Contractor shall:

- (1) Perform two tests per day for each mixture blend and then one per day if the test samples meet crushing requirement.
- (2) Take one sample per day and perform one test per week if samples exceed requirement by greater than 8 percent. If the 8 percent requirements are not met, (1) above must be followed.

2340.3

The Contractor shall take companion samples for Department verification of Contractor's QC tests. The Department will take or observe the taking of at least one audit QA sample per day. The Contractor shall split the audit sample so that sufficient material is provided for both the Contractor's test lab and the Department's QA laboratory. The Department shall test at least one audit sample on a Project. The Contractor may substitute an audit sample for a QC sample.

The Contractor shall obtain 0.5 L (**1 pint**) samples of asphalt at a rate according to the most recent Technical Memorandum of file with the Mn/DOT Materials Engineer.

A1e Documentation

The Contractor shall:

- (1) Number test results in accordance with standard Department procedures and record on forms supplied by the Department.
- (2) Facsimile all test results to the Materials Laboratory by noon of the day following production.
- (3) Take beginning and end of day asphalt tank measurements and supply information on asphalt quantities used for each Department Project.
- (4) Provide the Department with asphalt delivery invoices on a daily basis.
- (5) Be responsible for all requirements specified in 2340 and those requirements documented within Sections 5-693.400 and 5-693.700 of the Mn/DOT Bituminous Manual.
- (6) Provide a daily plant diary.
- (7) Provide weekly scale spot checks.
- (8) Provide a Department approved accounting system for all certified mixes and provide a daily and final Project summary of material quantities and types.
- (9) Furnish an automated weigh scale and computer generated weigh ticket. The ticket shall indicate Project number, certified mix designation, pit number, truck identification and tare, net mass, date and time of loading, and shall include the term "CERTIFIED". Any deviations from the minimum information to be provided on the computer generated weigh ticket must be approved by the Engineer in writing.

A1f Certified Plant Mixture Designations

The certified plant mixtures shall be designated according to Table 2331-1B.

E Mix Proportions

The Contractor shall comply with the requirements for mixture proportions in 2331.3E except as modified by the following:

2340.3

E1 Bituminous Material

The percentage of added asphalt cement designated shall have a working range tolerance of 0.3 percent, but not below the minimum asphalt content required for that mixture type. For recycled mixture containing salvaged asphaltic aggregate, the working range for added asphalt shall also provide an asphalt content that complies with the minimum total asphalt content requirement for that mixture type.

On individual spot checks, the percentage of added asphalt cement shall be within a tolerance of 0.3 percentage points of the plant setting, but not greater than 0.1 percentage points below the minimum values listed in Table 2331-1A (both added and total) asphalt content.

E2 Job Mix Formula (JMF)

E2b Contractor Trial Mix Design

The bituminous mix shall be designed by using only alternative 2331.3E2b, Contractor Trial Mix Design.

E2c Mixture Design Requirements

Mixture design requirements shall conform to 2331.3E2c except that the mixtures in Table 2331-1A shall conform to the following Fines to Asphalt (F/A) ratio requirement:

- (1) For all wearing courses 1.2 Maximum
- (2) For all non-wearing courses 1.5 Maximum

Trial mixture designs for all mixtures shall conform to the Voids in Mineral Aggregate (VMA) requirements listed below:

Minimum Voids in Mineral Aggregate

| <u>Aggregate Size</u> | <u>Design Air Voids 4.0 %</u> |
|-----------------------|-------------------------------|
| A | 15.0 % |
| B | 14.0 % |

The Contractor shall determine VMA by procedures and calculations contained in the Asphalt Institute Manual MS-2 and that the bulk specific gravity of the total aggregate shall be calculated according to either:

- (1) AASHTO T 84 and T 85 (required for mixtures containing steel slag), or
- (2) Procedures on file with the Bituminous Engineer using the following percent asphalt absorption factor (based on mass of aggregate):
 - (a) Using a 1.0 percent asphalt absorption factor for all mixtures (required for mixtures containing salvaged asphaltic aggregate) except Type 61 mixtures stated below.
 - (b) Using a 0.25 percent asphalt absorption factor for Type 61 mixtures containing 100 percent Class A aggregate, 100 percent taconite tailings, or a combination thereof.

E2d Mixture Production

Delete the JMF Working Range Table, Table 2331-2, and insert Table 2340-1.

The field test results may deviate from the JMF target value as follows; however, the Contractor shall target the center of the percent air void working range by adjusting gradation and asphalt content within the allowable working ranges.

**TABLE 2340-1
JMF WORKING RANGES (QC/QA)**

Specification Band Limits for Moving Average ^(B) - (N=4)

| Mix Characteristic | <u>Working Range</u> |
|--|-----------------------------|
| <u>Gradation:</u> | |
| 4.75 mm (#4) sieve or greater | +/- 5% |
| 2.00 mm (#10) and 425 µm (#40) sieves..... | +/- 4% |
| 75 µm (#200) sieve..... | +/- 2% |
| Bitumen Content (But not less than specified minimum)..... | +/- 0.3% |
| Air Voids (A) | 3.0% to 5.0% |

^(A) Based on moving (average of four tests) maximum specific gravity value with no individual test air void value less than 2.0 percent nor greater than 6.0 percent. The Contractor shall target the center of the percent air void working range. The air void requirement for mixture containing 100 percent taconite tailings is 4.0 percent or greater.

^(B) Moving Average - Based on four consecutive test results according to 2340.3E3c.

E2d(2) JMF Adjustments

The Contractor shall produce a mixture of uniform composition closely conforming to the approved JMF to ensure that the mixture when compacted will achieve the specified properties. If, during production, the Contractor determines from results of QC tests that adjustments are necessary to the mix design to achieve the specified properties, adjustments to the target JMF gradation and bitumen content values may be made within limits in Table 2340-2, without redesign of the mixture. The Contractor shall immediately report the changes and the new JMF to the Engineer and the Department's laboratory that approved the original mixture design.

Adjustments to the JMF, to conform to actual production values without redesign of the mixture, are based upon production of mixture at a target value of 4.0 percent air voids and a bitumen content not less than specified. Adjustments for target value and working range shall be limited to values listed in Table 2340-2 without a redesign of the mixture. The Bituminous Engineer may waive the adjustment

2340.3

limitation but the asphalt content (both added and total) shall not be less than the minimum required, and the gradation adjustment shall not be outside the aggregate gradation ranges listed in Table 3139-1 for that type and size aggregate.

Adjustments will be made as a result of the interactive process between Contractor, the Engineer, and the Bituminous Engineer.

Further adjustments to the JMF without redesign may be requested by the Department or the Contractor because of unsatisfactory results. The voids in the mineral aggregate of the mixture and the fines to asphalt ratio shall be reviewed prior to an approval of this adjustment by the Bituminous Engineer.

TABLE 2340-2

JMF WORKING RANGE ADJUSTMENTS (QC/QA)

| <u>Sieve Size</u> | <u>Adjustments</u> |
|---|--------------------|
| 16.0 mm (5/8 inch), 19.0 mm (3/4 inch), 25.0 mm (1 inch).... | +/- 5% |
| 9.5 mm (3/8 inch), 12.5 mm (1/2 inch)..... | +/- 4% |
| 4.75 mm (#4), 2.00 mm (#10), 425 µm (#40) | +/- 3% |
| 75 µm (#200)..... | +/- 1% |
| Bitumen Content | +/- 0.2% |

E3 Contractor Testing

The Contractor shall provide qualified personnel and sufficient equipment meeting the requirements listed in the Mn/DOT Bituminous Manual to conduct QC testing. The testing rates shall be in conformance with the Schedule of Materials Control for Bituminous Construction Items for Quality Assurance Projects.

The Contractor shall calibrate and correlate the testing equipment with prescribed procedures and conduct tests in conformance with specified testing procedures as listed in the Mn/DOT Bituminous Manual.

The Contractor shall store and retain Marshall samples and companion samples for the Department for a period of 7 days.

The Contractor shall maintain control charts on an ongoing basis.

Reports, records, and diaries developed during the progress of construction activities shall be filed as directed by the Engineer and will become the property of the Department.

The Contractor shall provide the following test data:

- (a) Copies of all test results, QC test summary sheets, and control charts at completion of bituminous operations on the Project to the Project Engineer. For Certified Plant Projects copies of all test results, QC test summary sheets, and control charts pertaining to

that specific Project shall be submitted to the Project Engineer at completion of bituminous operations on the Project.

NOTE: Because Certified Plant test data often represents test data for multiple projects, it may be necessary to make duplicate copies of the data for each Project.

- (b) Copies of all test results, QC test summary sheets, and control charts for a Certified Plant to the Bituminous Engineer. The Contractor shall provide this data that represents the year's production at a permanent location or the total production at a temporary location, at year's end for permanent locations and at the end of mixture production for temporary locations.
- (c) Copies of all failing test results (based on a moving average of four tests, when appropriate) and QC test summary sheet sent by facsimile on a daily basis to the Project Engineer.
- (d) Copies of the QC summary sheet sent by facsimile on a daily basis, when requested, to the District Materials Engineer (Bituminous Engineer for the Metropolitan District).

E3a Quality Control Organization

Along with the proposed mix design data, the Contractor shall submit to the Engineer an organizational chart listing the names and phone numbers of individuals and alternates responsible for mix design, process control administration, and inspection. The Contractor shall also post the organizational chart in the Contractor's test facility.

The Contractor's QC organization or private testing firm shall have Certified Technicians who have met the requirements on file with the Department. Individuals performing QC testing must be certified as a Level I Bituminous Quality Management (QM) Tester. Individuals performing mix design calculations or mix design adjustments must be certified as a Level II Bituminous QM Mix Designer. The Contractor shall have a minimum of one person per paving operation certified as a Level II Bituminous Street Inspector.

E3b Testing Facilities

The Contractor's testing facility shall be located at the plant site and be approved by the Engineer prior to the commencement of mixture production. Any other laboratory location must be approved by both the Engineer and Bituminous Engineer. Suitable space and specified testing equipment shall be provided for use by the Contractor's QC personnel to perform tests as required.

To facilitate communication between the Contractor and the Engineer regarding QC, the Contractor's testing facility shall be equipped with:

- (1) A telephone with a private line for the exclusive use of the testing facility's QC personnel and the Engineer.
- (2) A copying machine.

2340.3

(3) A facsimile machine.

E3c Testing Requirements.

All samples for tests shall be taken at random locations, selected by the Engineer, at the rates specified in the Schedule for Materials Control for Bituminous Construction Items for Quality Assurance Projects.

The tests for mixture properties and extraction shall be conducted on representative portions of the mix, quartered from a larger sample of mix taken at random behind the paver.

On the first day of production, the Engineer will observe the Contractor splitting the sample into three representative portions. The Contractor shall transport a sample of at least 25 kg (**55 pounds**) to the test facility by a method to retain heat to facilitate sample quartering procedures.

The test for mixture properties and extraction shall be conducted on three representative portions of the mix. The Engineer will observe the Contractor testing the sample. One part shall be compacted immediately while still hot (additional heating may be required to raise the temperature of the sample to compaction temperature). The second sample shall be allowed to cool to ambient air temperature and then be heated to compaction temperature and compacted. The third sample shall be allowed to cool to ambient air temperature and then be transported to the District laboratory where it will be heated to compaction temperature and compacted. From this information a calibration factor will be developed to compare the bulk specific gravity of hot compacted samples to reheated compacted samples. Each test will involve a minimum of three Marshall specimens. This test may be repeated at the discretion of the Contractor or the Department.

Note: Care must be taken when reheating samples for mixture property analysis tests. Mix samples should only be reheated to 70°C (**160° F**) to allow splitting of the sample into representative fractions for the various tests. Overheating of the mixture portion to be tested for maximum specific gravity (Rice Test) may result in additional asphalt being absorbed into the aggregate.

All test results and calculations shall be recorded and documented on data sheets approved by the Department. Specific test results shall be recorded on a daily summary sheet approved by the Department to facilitate the computation of moving test averages. Moving averages will be based on four consecutive test results. The Daily Quality Control Summary Sheet shall also include a description of QC actions taken (adjustment of cold feed percentages, changes in JMFs, etc.) in addition, QC charts shall be posted and kept current showing both individual test results and moving average values. As a minimum, the following values shall be plotted on Department approved control charts:

2340.3

- (1) Asphalt content by the spot check method to the nearest 0.1 percent.
- (2) Gradation of virgin aggregate and non-asphaltic aggregate used in virgin and recycled mixtures and extracted gradation for Types 32, 42, and 48 mixtures containing salvaged asphaltic aggregate. The gradations shall include percent passing all Specification sieves to the nearest whole percent (75- μm (#200) sieve to the nearest 0.1 percent).
- (3) Maximum specific gravity (Rice Test) to 3rd decimal point.
- (4) Percent air voids determined from the average of a minimum of three Marshall specimens.
- (5) Extraction and gradation (See (2) above) for Types 32, 42, and 48 mixtures containing salvaged asphaltic aggregate. Testing shall include determination of the mixture moisture correction factor.
- (6) Percent air voids in the compacted pavement determined from cores when compaction is by the Specified Density Method.

Individual test results shall be plotted in black for each test point. A solid black line shall connect points. The moving average for each test variable shall be plotted in red starting with the fourth test. A dashed red line shall connect the points. The Department's acceptance test results shall be plotted with green asterisks. The average of the first four maximum specific gravity tests (first moving average point) shall be used to compute Marshall air voids for the first three tests. The first moving value for percent air voids shall be based on these three values and the results of the fourth test value.

Specification working range limits shall be indicated on the control charts using a green inked dotted line.

E3d Response to Test Results

When the moving average trend line for any property value for a test indicates that the process is moving toward the limits of the Specification, the Contractor shall increase the sampling and testing rate. The Contractor shall notify the Engineer whenever the process approaches the Specification limits. Two consecutive moving average points outside the Specification limits shall be cause to cease operations. The Contractor shall assume the responsibility to cease operations. The Contractor shall not start operations again without approval of the Engineer.

Failure to cease operations after two consecutive moving average points fall outside the Specification limits shall subject all subsequent material to 1512.

Mixture placed with laboratory voids (moving average of four) equal to or greater than 1.0 percent below the allowable minimum or equal to or greater than 1.0 percent above the allowable maximum will be subject to removal and replacement or a price reduction at the

2340.3

discretion of the Engineer. Mixture placed with laboratory voids (moving average of four) less than 1.0 percent below the allowable minimum or less than 1.0 percent above the allowable maximum may be subject to a price reduction. This action shall apply to the Contractor's test results as verified by the Department's laboratory.

The Department will examine individual test failures that result from problems beyond the Contractor's normal QC testing variation. The investigation may be based on either the Contractor's or the Department's test results. The information from additional testing (including testing of in-place pavement) may be used to define unacceptable work in accordance with 1512 and to apply appropriate price reductions or to initiate corrective action, as determined by the Engineer.

For any test, if the Engineer determines that the Contractor's results are faulty, action will be based on the Department's laboratory results.

H Compaction Operations

The Contractor shall comply with the compaction requirements specified in 2331.3H except when modified and supplemented by the following:

H2 Modified Specified Density Method (Percent of Maximum Theoretical Density)

Delete 2331.3H2 and insert the following:

The Contractor shall have two options for obtaining the density measurements. Option No. 1 is the Coring Option and Option No. 2 is the Nuclear Gauge Option. Both Options are described below.

H2a Density Lots

H2a(1) Production Rates of 1000 Metric Tons (**1000 tons**) per Day or Greater

For the modified specified density method of compaction, determination of the density in the compacted mixture shall be made on samples taken by the Contractor from each lift placed. Samples shall be taken from randomly selected sites as directed by the Engineer within a lot representing a days production. The samples shall be taken prior to placement of the next lift and no later than the next working day following the date of placement. If 1-day's production from any lift is less than 500 metric tons (**500 tons**), it may be combined with the next day's production of that lift to form a lot. Acceptance will normally be made in lots equal to the number of metric tons (**tons**) placed in each lift on each production day. Each lot will be divided into five sublots of approximately equal surface area.

H2a(2) Production Rates Less than 1000 Metric Tons (**1000 tons**) per Day

For low daily production rates (less than 1000 metric tons (**1000 tons**)), the density requirement shall be based on the number of

cores listed in the following table. Additional companion cores shall be taken by the Contractor and observed by the Department for verification testing. If the average density of cores taken is less than 91 percent of maximum density, the Contractor shall have the option to take additional cores to provide a minimum of 10 cores, or to accept a penalty based on the results of the cores already taken. Density requirements shall be as listed below.

| Daily Production Metric Tons (Tons) | Cores Required (Number) | Companion Cores Required (Number) |
|---|-------------------------------|---|
| 0-272 (0 - 300) | 2 | 1 |
| 273-545 (301-600) | 4 | 2 |
| 546-910 (601-1000) | 6 | 2 |
| 911+ (1001+) | 10 | 3 |

H2b Optional Density Methods (No. 1 and No. 2)

The Contractor shall use the coring method of testing (Option No. 1) for density but may select the nuclear gauge option (Option No. 2) for obtaining some of the density measurements.

H2b(1) Cores (Option No. 1)

Two cores shall be taken at random within each subplot. The Contractor may be required to chill the compacted mixture before coring samples so that the samples may be removed intact without distortion. The samples shall be cut using a 100 to 150 mm (**4 to 6 inches**) coring device. All samples shall be marked with the lot number, subplot number, and core number or letter. The cores shall be transported to the laboratory as soon as possible to prevent damage due to improper handling or exposure to heat.

Cores shall not be taken within 0.3 m (**1 foot**) of a longitudinal joint or edge nor within 6 m (**20 feet**) of a transverse joint.

The Engineer may allow recoring of a sample only when the core has been damaged, through no fault of the Contractor, either during the coring process or in transit to the laboratory. Recoring will not be allowed for any other reason unless written approval is obtained from both the Engineer and the Bituminous Engineer or the District Materials Engineer.

Companion cores shall be taken at three of the coring locations as selected by the Engineer for testing at the Department's laboratory. This is to verify the reliability of the Contractor's test results and to serve as acceptance tests. Payment factors will be based on the Contractor's core results as observed by the Engineer and verified by the three cores sent to the Department's laboratory.

The core holes shall be dried, filled with the same type of material, and the material properly compacted by the next working day.

The Contractor shall test the cores in the presence of the Engineer.

2340.3

H2b(2) Nuclear Gauge (Option No. 2)

The compaction and testing requirements are the same as those under Option No. 1; however, the Contractor may measure the in-place densities with a nuclear density gauge rather than the cores.

H2b(2)(a) Testing

The Contractor shall provide a nuclear gauge that is on the approved list on file with the Materials Engineer and provide a competent operator.

The Contractor shall perform a function check on the nuclear gauge before using it on the Project each day according to the procedure listed in the operator's manual. The Contractor shall perform testing in the presence of an inspector.

H2b(2)(b) Nuclear Gauge Calibration

The Contractor shall calibrate the equipment on the actual Project paving.

The nuclear gauge must be calibrated with each mixture type (JMF) and lift thickness in order to convert the nuclear readings to true densities. The calibration factor will be determined by comparing the mean of 10 cores with the mean of 20 nuclear gauge readings taken on the first day of paving with a specific mixture type (JMF) and layer thickness.

The Contractor shall calibrate and recalibrate the gauge whenever the mixture type (JMF) or lift thickness changes. Recalibration may also be required when the underlying base material changes, especially when testing layers less than 50 mm (**2 inches**) thick. The Engineer may require, or the Contractor may request, recalibration whenever there is reason to believe conditions have changed that may affect the accuracy of the gauge readings.

H2b(2)(c) Gauge Calibration Procedure

On the first day of paving with a specific mixture type (JMF) and lift thickness, cores will be required the same as under Option No. 1. Nuclear density measurements and cut pavement density samples shall always be taken at the same randomly selected locations. Core and cut samples shall be taken by the Contractor immediately following nuclear testing. Core and cut samples shall be tested promptly for bulk specific gravity following methods in the Mn/DOT Bituminous Manual. The nuclear gauge readings shall consist of two readings taken parallel with centerline (or rolling direction) at directions 180 degrees apart.

If the difference in the two density readings varies by more than 48 kg/m^3 (**3 pounds per cubic foot**) at any one location, two additional readings shall be taken. If the difference between the two additional readings (taken 180 degrees apart in direction) is also greater than 48 kg/m^3 , (**3 pounds per cubic foot**) another nearby test location shall be selected. If the difference between the second set of two readings is

2340.3

48 kg/m³ (**3 pounds per cubic foot**) or less, the average of the second set of readings shall be used for density measurement. If continued differences greater than 48 kg/m³ (**3 pounds per cubic foot**) occur, contact the Engineer and the Bituminous Office for advice on proceeding.

The calibration factor will be calculated by subtracting the mean gauge reading from the mean core densities. The calibration factor can be either positive or negative number.

The calibration factor is only good for the specific nuclear gauge and type of mixture and lift thickness used during calibration. If a gauge is damaged or does not pass the daily function check and a new gauge is required, the Contractor shall determine a new calibration factor with new cores.

H2b(2)(d) Density Compliance and Acceptance

Density compliance and acceptance shall meet the requirements listed below, except the average of two nuclear density gauge readings will be used instead of one core density at each test site. The average gauge readings used to determine compliance shall be adjusted with the appropriate calibration factor determined for the specific mixture type (JMF) and layer thickness.

If the Contractor believes the density results obtained with the nuclear gauge are incorrect, the Contractor may obtain cores from the same locations where the nuclear readings were taken and base density compliance on the core results. If this option is used, the cores must be obtained within 24 hours after placement of the bituminous mixture.

H2c Density Requirement

The density shall be 91 percent of the maximum specific gravity value based on the grand average of the five subplot averages (N=10), with no individual subplot average less than 89 percent of the maximum specific gravity. The maximum specific gravity value used to calculate the percentage density shall be the average value of all tests conducted the same day the lot was placed and compacted. This value shall be used for all density lots placed that same day. If only one or two maximum specific gravity values were obtained that day, then the moving average value (at that test point) shall be used. If three or more maximum specific gravity values are obtained that day, then the average of those tests alone shall be used as indicated above.

No retests will be permitted for failing densities.

H2d Payment

Payment for compaction of the completed pavement will be by lot based on the percentage of maximum specific gravity obtained.

Pay factors be determined from Table 2340-3.

2340.3

**M Bituminous Mixture Production
(FOB Department Trucks) 2331.3M**

The Engineer may require the Contractor to sample 2340 mixtures behind the paving operation. The mixture will not be subject to Contractor density testing.

**TABLE 2340-3
PAY FACTORS FOR MODIFIED SPECIFIED DENSITY
(QC/QA)**

| Mean of 10 Cores or Nuclear Gauge Density | |
|--|----------------------------|
| <u>as % of Maximum Specific Gravity</u> | <u>Pay Factor A</u> |
| 91.0% or greater | 1.00 |
| 90.0% to 90.9% | 0.99 |
| 89.0% to 89.9% | 0.975 |
| 88.0% to 88.9% | 0.95 |
| 87.0% to 87.9% | 0.925 |
| Less than 87.0% | (A) |
| Lowest Mean of Any | |
| <u>Sublot Average</u> | <u>Pay Factor B</u> |
| 89.0% or greater | 1.00 |
| 88.0% to 88.9% | 0.99 |
| 87.0% to 87.9% | 0.98 |
| 86.0% to 86.9% | 0.97 |
| 85.0% to 85.9% | 0.96 |
| Less than 85.0% | (A) |

(A) The Engineer will determine whether the material may remain in place. The pay factor for such material remaining in place shall be 0.70 for Pay Factor A and 0.80 for Pay Factor B.

$$\text{Total Pay Factor} = (\text{Pay Factor A}) \times (\text{Pay Factor B})$$

**M Bituminous Mixture Production
(FOB Department Trucks) 2331.3M**

The Engineer may require the Contractor to sample 2340 mixtures behind the paving operation. The mixture will not be subject to Contractor density testing.

**N Delete 2331.3N Bituminous Mixtures Measured by the
Square Meter (Yard) per Specified mm (inch) Thickness**

2340.4 BASIS OF MEASUREMENT

The method of measurement will be the same as 2331.4 except as modified by the following:

D Delete 2331.4D Bituminous Mixtures Measured by the Square Meter (Yard) per Specified mm (inch) Thickness

E Contractor Testing

When a pay item for Contractor testing is specified in the Contract, measurement will be based on the mass of plant mixed bituminous mixture used and tested.

2340.5 BASIS OF PAYMENT

The basis of payment will be the same as that specified in 2331.5, except that payment by the square meter (**yard**) per specified mm (**inch**) thickness is deleted. Unless otherwise specified in the Contract, the cost for Contractor testing will be incidental to the bituminous mixture pay item.

Payment will be made on the basis of the following schedule:

| Item No. | Item | Unit |
|-----------------|--|-------------------------------------|
| 2340.501 | Contractor Testing ^(A) | metric ton (ton) |
| 2340.508 | Type__ Wearing Course Mixture | metric ton (ton) |
| 2340.510 | Type__ Binder Course Mixture | metric ton (ton) |
| 2340.512 | Type__ Leveling Course Mixture | metric ton (ton) |
| 2340.514 | Type__ Base Course Mixture | metric ton (ton) |
| 2340.516 | Type__ Shoulder Mixture | metric ton (ton) |
| 2340.518 | Type__ Bituminous Mixture for | |
| | Specified Purpose | metric ton (ton) |
| 2340.521 | Irregular Width Paving | square meter (square yard) |
| 2340.549 | Type__ Bituminous Mixture Production | |
| | | metric ton (ton) |

NOTE: If either mineral filler or hydrated lime is required in any bituminous mixture item, the item name must be expanded by adding the words: (with Filler) or (with Lime).

^(A) Payment for item No. 2340.501, Contractor Testing by the metric ton (**ton**), will be made only when the pay item is specified in the Contract. If specified, payment for the Contractor testing of the plant mixed bituminous surface will be compensation for all costs of the required testing.

2350

2350
Plant Mixed Asphalt Pavement
Quality Control/Quality Assurance
(Type LV, MV, HV)

2350.1 DESCRIPTION

This work consists of the construction of one or more pavement courses of hot plant mixed asphalt-aggregate mixture on the approved prepared foundation, base course or existing surface in accordance with the specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer.

2350.2 MATERIALS

A Aggregate

A1 General Requirements

The aggregate blend used in the work shall conform to the requirements of 3139, for this particular material specified, except as hereinafter otherwise or additionally stipulated.

Class B carbonate aggregate shall be limited in 2350 mixtures as follows:

Table 2350-A1
Aggregate Restriction

| Mixture Type | Maximum % minus 4.75 mm (-#4) | | Maximum % plus 4.75 mm (+#4) | |
|------------------------|----------------------------------|----------|---------------------------------|----------|
| | Wear | Non wear | Wear | Non wear |
| LV, MV | 100 | 100 | 100 | 100 |
| HV | 80 | 80 | 50 | 100 |
| HV > 10 million ESAL's | 50 | 80 | 0 | 100 |

A2 Aggregate Gradation for Asphalt Mixtures

The combined aggregates, including mineral filler when required, shall conform to the following gradation requirements.

**Table 2350-1
Broad Band Aggregate Gradation for Asphalt Mixtures
(% passing of total washed gradation)**

| Sieve Size mm (in) | 1 | 2 | 3 | 4 | 5* |
|-----------------------|--------|--------|--------|--------|-------|
| 37.5 (1-1/2 inch) | 100 | - | - | - | - |
| 25.0 (1 inch) | 90-100 | 100 | - | - | - |
| 19.0 (3/4 inch) | 55-90 | 90-100 | 100 | - | - |
| 12.5 (1/2 inch) | - | 45-90 | 90-100 | 100 | - |
| 9.5 (3/8 inch) | - | - | 35-90 | 90-100 | 100 |
| 4.75 (#4) | 15-70 | 20-75 | 20-80 | 25-85 | 65-95 |
| 2.36 (#8) | 10-55 | 15-60 | 15-65 | 20-70 | 45-80 |
| 0.075 (#200) | 2-7 | 2-7 | 2-7 | 2-7 | 2-7 |

* Gradation 5 is intended for thin lift leveling.

B Additives

An additive is any material added to an asphalt mixture or material, such as mineral filler, hydrated lime, asphalt additives, anti-strip, and similar products that do not have a specific pay item. When a Contract requires additives, compensation is included with the pay items for the appropriate mixture. If the Engineer directs the Contractor to incorporate additives, the compensation will be as Extra Work. The Department will not compensate the Contractor for additives incorporated at the Contractor's option.

Additives shall not be incorporated into the mixture without approval of the Department Bituminous Engineer. Anti-foaming agents shall be added to asphalt cement at the manufacturer's recommended dosage rate. Mineral filler and hydrated lime may be added in a quantity not to exceed 5 percent and 2 percent, respectively, of the total mass of the aggregate. The combination of mineral filler and hydrated lime shall not exceed 5 percent of the total mass of aggregate. The Engineer will approve or disapprove methods for addition of additives.

B1 Mineral Filler..... 3145

2350.2

B2 Hydrated Lime..... 3145

Hydrated lime used in asphalt mixtures shall meet the requirements of ASTM C977 and have a maximum of eight percent unhydrated oxides (as received basis). The method of introducing and mixing the hydrated lime and aggregate shall be subject to approval by the Engineer prior to beginning mixture production.

B3 Liquid Anti-Stripping Additive

When a liquid anti-strip additive is added to the asphalt binder, blending shall be completed before the asphalt binder is mixed with the aggregate. Liquid anti-strip additives that modify the asphalt binder, such that it fails to meet the Performance Grade (PG) requirements, shall not be used. No paving will be allowed until the asphalt binder / additive blend has been tested and the results meet the criteria in 2350.2F. The Company adding the additive will be responsible for testing the binder / additive blend to ensure compliance with the standard specification for performance graded asphalt binder AASHTO MP-1 .

B4 Coating and Anti-Stripping Additive..... 3161

C Recycled Asphaltic Pavement Materials (RAP)

The Contractor may use up to 30 percent recycled asphaltic pavement (RAP) in all wearing layers and High Volume (HV) non wear layers. Medium Volume (MV) mixtures may contain a maximum of 30% RAP in the non wear layers above 90 mm (**3.5 inch**) and a maximum of 40% RAP in layers 90 mm (**3.5 inch**) and greater in depth from the surface. Low Volume (LV) mixtures may contain a maximum of 40% RAP in the non wear layers. The combined RAP and virgin aggregate shall meet the composite fine aggregate angularity or crushed requirements (both coarse and fine aggregate) for the mixture being produced. The RAP sand will be considered 50 percent crushed if the Angularity Index, according to ASTM C1252 Method A, equals or exceeds 40, and 100 percent crushed if the Angularity Index equals or exceeds 45.

RAP containing any objectionable material, i.e., road tar, metal, glass, wood, plastic, brick, fabric, or any other objectionable material having similar characteristics will not be permitted for use in the asphalt pavement mixture.

Asphalt binder content in the RAP shall be determined according to Mn/DOT Lab Manual Method 1851 or 1852.

C1 Asphalt Binder Selection Criteria for All Mixtures with RAP

The following summarizes the criteria for adjusting the asphalt binder grade when RAP is included in an HMA mixture.

| | ≤20% RAP | >20% RAP |
|------------------|------------------------------|------------------------------|
| Overlay | No grade adjustment required | No grade adjustment required |
| New Construction | No grade adjustment required | See Table below |

New Construction >20% RAP

| Specified Asphalt Binder Grade | New Asphalt Binder Grade used with RAP |
|--------------------------------|--|
| PG 64-34 | > 20% RAP Not Allowed |
| PG 58-34 | PG 52-34 |
| PG 64-28 | PG 64-28 |
| PG 58-28 | PG 52-34 |
| PG 52-34 | PG 52-34 |
| All other grades | Contact Department Bituminous Engineer |

The binder grade can also be selected by using the appropriate blending chart approved by the Bituminous Office if the mix designer chooses to adjust the binder selection to compensate for the stiffness of the reclaimed asphalt binder.

D Crushed Concrete and Salvaged Aggregate

Crushed concrete is allowed as an aggregate source for up to 50 percent of the aggregate in non wear mixtures. Crushed concrete is not allowed in wearing courses.

Salvaged aggregate is allowed as an aggregate source for up to 100 percent of the aggregate in wearing and non wearing mixtures. All salvaged aggregate shall be stockpiled uniformly to limit variation in mixture properties. Salvaged aggregates shall meet quality and crushing requirements as specified herein.

2350.2

E Scrap Shingles

Scrap shingles, as an asphalt binder source, may be included in both wear and non wear courses to a maximum of 5 percent of the total weight of mixture when approved by the Engineer. Only scrap shingles from manufacturing waste are suitable. The percentage of scrap shingles used will be considered part of the maximum allowable RAP percentage. Scrap Shingle Specifications are on file in the Bituminous Office.

F Asphalt Binder MaterialAASHTO MP-1

Asphalt binder material shall meet the requirements of PG asphalt binder testing tolerances, sampling rates, testing procedures, and acceptance criteria based on the most current Mn/DOT Technical Memorandum, titled "Inspection, Sampling, and Acceptance of Bituminous Materials." The PG asphalt binder cannot be modified with air blowing procedures unless it is approved by the Bituminous Office. The Contractor shall not use petroleum distillates such as fuel oil, diesel fuel or other fuels in the asphalt tanks.

G Asphalt Mixture Requirements

**Table 2350-2
Mixture Requirements**

| Mixture Property | High Volume HV | Medium Volume MV | Low Volume LV |
|--|----------------|-----------------------|---------------|
| 20 year Design ESAL's | > 3 million | 1-3 million | < 1 million |
| Marshall Blows | 75 | 50 | 50 |
| Stability, minimum N (pounds) | 6000 (1350) | 6000 (1350) | 5000 (1125) |
| Air Voids, % | 4.0 | 3.5 | 3.0 |
| Fines/Asphalt ^{effective} Ratio Wear: | 0.6 - 1.30 | 0.6 - 1.30 | 0.6 - 1.30 |
| Fines/Asphalt ^{effective} Ratio Non wear: | 0.6 - 1.40 | 0.6 - 1.40 | 0.6 - 1.40 |
| Tensile Strength Ratio ⁽¹⁾ , min % | 70 | 70 | 70 |
| Coarse Aggregate One Faced %: | 85 | 55 | - |
| Aggregate Two Faced %: | 60 | - | - |
| Angularity (CAA) | | | |
| Fine Aggregate Angularity (FAA) ⁽²⁾ | 44.0 | 40.0 | - |
| Manufactured Crushed fines, % ⁽²⁾ | 75 | 25 | - |
| Max. allowable RAP percentage, Wear | 30 | 30 | 30 |
| Max. allowable RAP percentage, Non wear | 30 | 30, 40 ⁽³⁾ | 40 |

- (1) Moisture susceptibility (TSR) test specimen shall be 100 mm (4 inch)
- (2) Either method may be used, however the choice must be made prior to start of production.
- (3) MV may contain 40 % RAP below 90 mm (3.5 inch) from the surface.

2350.3

Shoulder mixture placed in a separate paving operation shall be designed for 3.0 percent air voids.

**Table 2350-3
Voids in Mineral Aggregate (VMA) Mixture Requirements**

| Gradation | Fine Mixture % pass 4.75 mm (#4) | VMA Minimum | Coarse Mixture % pass 4.75 mm (#4) | VMA Minimum |
|-----------|----------------------------------|-------------|------------------------------------|-------------|
| 1 | > 35 | 13.5 | ≤ 35 | 13.0 |
| 2 | > 40 | 14.0 | ≤ 40 | 13.5 |
| 3 | > 45 | 15.0 | ≤ 45 | 14.5 |
| 4 | > 50 | 16.0* | ≤ 50 | 15.5* |
| 5 | > 65 | 16.0* | ----- | ----- |

*For LV 4 & LV 5 mixes lower VMA requirements by 0.5%.

2350.3 MIXTURE DESIGN

A Mixture Design General

The asphalt mix may be designed using either one of the following Contractor trial mix design options. Review and approval of mixture designs will be performed in the District Materials Laboratory where the project is located. The addition of aggregates and materials not included in the original mixture submittal is prohibited.

Proportion changes which exceed 10% of any single stockpile aggregate, from the original mix design submittal, will be considered a new mix design. New mix designs must meet the specification requirements shown in tables 2350-1, 2 & 3.

B Laboratory Mixture Design (Option 1)

Test results and documentation as described in section 2350.3D shall be submitted with the materials described below for consideration by the Department Bituminous Engineer or District Materials Engineer to verify compliance with these specifications and to issue a Department approved HMA Paving Recommendation.

B1 Aggregate sample

At least 15 working days prior to the start of asphalt production, the Contractor shall submit to the Department Bituminous Engineer or the District Materials Engineer a 35 kg (**80 pound**) sample of representative aggregate retained on the 4.75 mm (# 4) sieve and a 15 kg (**35 pound**)

2350.3

sample of material passing the 4.75 mm (#4) sieve. These samples will be tested for quality of each source, class, type, and size of virgin and non-asphaltic salvage aggregate source used in the mix design.

Aggregates that require the magnesium sulfate soundness test (as defined in 3139) shall be submitted to the Department Bituminous Engineer or District Materials Engineer at least 30 calendar days prior to the start of asphalt production.

B2 Mixture sample

At least 7 working days prior to the start of asphalt production, the Contractor shall submit in writing a proposed Job Mix Formula (JMF) for each combination of aggregates to the Department Bituminous Engineer or District Materials Engineer for review and approval. This proposed JMF must be signed by a level II Quality Management mix designer. For each JMF submitted, the Contractor shall include test data to demonstrate conformance to properties as specified in Table 2350-2 and 2350-3. The proposed JMF shall be submitted on forms approved by the Department. In addition, the Contractor shall submit a 15 kg (**35 pound**) uncompacted sample plus three Marshall briquettes compacted at the optimum asphalt content and Marshall design blows conforming to the JMF for laboratory examination and evaluation.

B3 Tensile Strength Ratio sample

Mixture or Marshall specimens, that represent the mixture at optimum asphalt content, shall be submitted at least 7 days prior to actual production for verification of moisture sensitivity retained tensile strength ratio (TSR). Material submitted for TSR verification may be tested for maximum specific gravity G_{mm} compliance in addition to TSR results. Failure to meet the G_{mm} tolerance will result in rejection of the submitted mix design. A new mix design submittal will be required and will be subject to provisions described in 2350.3D. One of the following options may be used to verify that the tensile strength ratio (TSR) meets the requirements in Table 2350-2.

Option 1) The Contractor will batch material at the design proportions including optimum asphalt. Immediately (before curing) split sample and allow samples to cool to room temperature. Submit 25 kg (**55 pounds**) of mixture to the District Materials Laboratory for curing and test verification. Both groups will use a 2 hour cure time (± 15 minutes) at 135°C and follow remaining procedures in ASTM D 4867-92, Mn/DOT modified.

Option 2) The Contractor batches, cures (as indicated in option #1), compacts, and submits a minimum of 6 Marshall specimens at the required 6-8% void content and 8200 grams of uncompacted mixture.

C Produced Mixture Design (Option 2)

Test results and documentation as described in section 2350.3D shall be submitted with materials described below for consideration by the Department Bituminous Engineer or District Materials Engineer to verify

2350.3

compliance with these specifications and issuance of a Department approved HMA Paving Recommendation.

C1 Aggregate Sample

At least 15 working days prior to supplying mixture to a Department Project, the Contractor shall submit to the Department Bituminous Engineer or the District Materials Engineer a 35 kg (**80 pound**) sample of representative aggregate retained on the 4.75 mm (**#4**) sieve and a 15 kg (**35 pound**) sample of material passing the 4.75 mm (**#4**) sieve. These samples will be tested for quality of each source, class, type, and size of virgin and non-asphaltic salvaged aggregate source used in the mix design.

Aggregates that require the magnesium sulfate soundness test shall be submitted to the Department Bituminous Engineer or District Materials Engineer at least 30 calendar days prior to the start of asphalt production.

C2 Mixture Sample

At least 5 working days prior to supplying mixture to a Department project, the Contractor shall provide the Department Bituminous Engineer or District Materials Engineer with the data and samples of material from at least four consecutive quality control test results, as shown in 2350.5C3a, representing the most recent Quality Management certified production of the mixture for review and approval. The Contractor shall supply sufficient material or Marshall specimens as described in option 1 for verification of Tensile Strength Ratio. If these test results show the mixture to be in compliance with the requirements of Table 2350-1, Table 2350-2, and Table 2350-3 a paving recommendation may be issued based on previously produced material. Compliance shall include the moving average of 4 test results compared to the warning limits and each single test result as compared to twice the warning limits shown in Table 2350-4.

D Documentation

Each proposed JMF submitted under 2350.3B and 2350.3C shall include the following documentation and test results.

- (1) The name(s) of the individual(s) responsible for the Quality Control of the mixture during production.
- (2) The low Project number on which the mixture will be used.
- (3) The percentage in units of 1 percent (except the 0.075 mm (**#200**) sieve in units of 0.1 percent) of aggregate passing each of the specified sieves for each aggregate to be incorporated into the mixture. The gradation of aggregate from salvaged asphaltic material shall be derived from the material after the residual asphalt has been extracted.
- (4) The proportion of each material (in percent of total aggregate).
- (5) The composite gradation based on (3) and (4) above. Note: Include virgin composite gradation based on (3) and (4) above for mixtures containing RAP.

2350.3

- (6) The test results from the composite aggregate blend at the proposed JMF proportions indicating compliance with fine aggregate angularity uncompact voids as shown in Table 2350-2. Or calculated - 4.75 mm (#4) crushing from the composite blend of the proposed JMF. Selection of either FAA or - 4.75 mm (#4) crushing shall be made at the time of mix design submittal. This selection will dictate the choice of method used for determination of compliance and acceptance for the duration of time the Department approved Mixture Recommendation is in force.
- (7) The bulk (dry) and apparent specific gravities and water absorption (by % weight of dry aggregate) of both coarse and fine aggregate, for each product used in the mixture (including RAP). Use AASHTO T-84 and T-85 test methods with modifications on file in the Bituminous Office. The tolerance allowed between the Contractor's and the Department's specific gravities are G_{sb} (individual) = 0.040 and G_{sb} (combined) = 0.020.
- (8) The composite gradation plotted on a FHWA 0.45 power chart. (Federal form PR-1115)
- (9) For mixtures containing RAP include extracted asphalt content of the RAP with no retention factor included.
- (10) The percentage (in units of 0.1 percent) of asphalt binder material to be added, based upon the total mass of the mixture.
- (11) When using mixture design option 1, include the following:
 - (a) A mix design with a minimum of three different asphalt contents (minimum 0.4 percent between each point), with at least one point at, one above and one below the optimum asphalt percentage.
 - (b) The maximum specific gravity at each bitumen content. The theoretical maximum specific gravity used for percent air voids determination shall be calculated based on the average of the effective specific gravities measured by a minimum of two maximum specific gravity tests at the asphalt contents above and below the expected optimum asphalt content.
 - (b) The Marshall test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimens at each bitumen content.
 - (c) The percent air voids in the mixture at each bitumen content.
 - (d) The percent Voids in Mineral Aggregate (VMA) at each bitumen content.
 - (e) The Fines to Effective Asphalt (F/A) ratio calculated to the nearest 0.1 percent.
12. The results of Tensile Strength Ratio (TSR) tests, conducted according to ASTM D4867 as modified by Mn/DOT

E HMA Paving Recommendation

A Department approved Paving Recommendation includes a job mix formula (JMF) from the composite gradation, aggregate component proportions, and asphalt content of the mixture. Design air voids, Voids in Mineral Aggregate, and aggregate bulk specific gravity values are indicated on the paving recommendation also. Warning limits and JMF limits will be shown for gradation control sieves, percent asphalt binder content, air voids, and VMA.

A Department approved paving recommendation is required for all paving except for small quantities of material provided under 2350.4H. All submitted materials must meet aggregate and mixture design requirements before a paving recommendation is issued. The Department will verify two trial mix designs per mix type designated in the plan, per Contract at no cost to the Contractor. Additional mix designs will be verified at a cost of \$2000 per design, payable to the Commissioner of Transportation.

For city, county, and other agency projects that do not have federal or state-aid funding, the Contractor shall provide to the District Materials Laboratory a complete Project proposal including addenda, supplemental agreements, change orders, and any Plan sheets (including typical sections) that affect the mix design. The Department will not start the verification process without this information.

All test procedures and required forms are on file with the Department Bituminous Engineer. Test tolerances are described in section 2350.5D

2350.4 CONSTRUCTION REQUIREMENTS**A General**

The following construction requirements provide for the construction of all courses. When construction is under traffic, the requirements of the Standard Specifications 2221.3D will apply.

B Restrictions

In general, no work within the roadway will be permitted in the spring until seasonal load restrictions on roads in the vicinity have been removed. However, work within the roadbed may be permitted before that time if, in the opinion of the Engineer, it can be done without damage to the subgrade. HMA shall not be placed when, in the opinion of the Engineer, the weather or road bed conditions are unfavorable.

No asphalt pavement wearing course shall be placed after October 15th in that part of the state north of an east-west line between Browns Valley and Holyoke, nor after November 1st south of that line. The Engineer may waive these restrictions when:

- (1) The asphalt mixture is not being placed on the traveled portion of the roadway, or

2350.4

- (2) The roadway involved will not be open to traffic during the following winter, or
- (3) The Engineer directs in writing the mixture be placed.

The Contractor shall not use petroleum distillates such as kerosene and fuel oil to prevent adhesion of asphalt mixtures in pavement hoppers, truck beds, or on the contact surfaces of the compaction equipment. Anti-adhesive agent must meet the criteria for "Effect on Asphalt" as described in the most recent Asphalt Release Agent Report on file in Mn/DOT's Office of Environmental Services and the Bituminous Office.

C Equipment

C1 Asphalt Mixing Plants

C1a Requirement for All Plants

The Contractor shall test and calibrate all scales according to Mn/DOT Standard Specifications section 1901, except as otherwise designated by the contract.

C1a(1) Equipment for the Preparation of the Aggregate

Add mineral filler to the mixture using a storage silo equipped with a device to ensure a constant and uniform feed.

C1a(2) Equipment for the Preparation of Asphalt Material

Tanks for storage of asphalt material at the plant shall be equipped to heat the material and maintain the material at the required temperatures. The discharge end of the circulating line shall be below the surface of the asphalt material. Provide agitation for modified asphalt, when used, if recommended by the supplier.

An outage table or chart and measuring stick shall be provided for each storage or working tank. Tanks shall be equipped with provisions for taking of asphalt binder material samples. After delivery of asphalt binder material to the Project, the Contractor shall not heat the material above 175°C (**350 °F**). For modified asphalt, the maximum storage temperature shall not exceed the recommendation of the asphalt supplier.

C1a(3) Asphalt Binder Control

When asphalt binder material is proportioned by volume, the plant shall be equipped with either a working tank or a metering system for determining bitumen content of the mixture.

The working tank shall have a capacity between 3800 L (**1000 gallon**) and 7600 L (**2000 gallon**). The working tank shall be calibrated and supplied with a calibrated measuring stick. The tank may be connected to a mixing unit and used only during spot check operations, but it shall be available at all times. Any feedback shall be returned to the working tank during spot check operations.

The metering system shall consist of at least one approved bitumen flow meter in addition to the bitumen pump. The flow meter shall be connected to the bitumen supply to measure and display only the bitumen

2350.4

being fed to the mixer unit. The meter readout shall be positioned for convenient observation. Means shall be provided for comparing the flow meter readout with the calculated output of the bitumen pump. In addition, the system shall display in liters (**gallon**) or to the nearest 0.001 metric ton (**0.001 ton**), the accumulated bitumen quantity being delivered to the mixer unit. The system shall be calibrated and adjusted to maintain an accuracy of \pm one percent error. This calibration shall be required for each plant set-up prior to production of mixture.

C1a(4) Dryer: The aggregate shall be free of unburned fuel.

C1a(5) Thermometric Equipment:

The plant shall be equipped with a sufficient number of thermometric instruments to ensure temperature control of the aggregate and the asphalt binder material.

C1a(6) Pollution Controls

C1a(6)(a) Pollution 1717

C1a(7) Surge and Storage Bins

The plant may include facilities to store hot asphalt mixture for coordinating the rate of production with the paving operations. Storage of the hot mixture will be permitted for a period not to exceed 18 hours, provided the following requirements are met:

- (a) Hot mix storage facilities shall be designed and operated to prevent segregation of the mix, drainage of the asphalt from the mix, and to prevent excessive cooling or overheating of the mixture.
- (b) The temperature of the mixture at time of discharge from the storage facility shall be within a tolerance of 5°C (9 °F) of the temperature when discharged from the silo or mixer.

C2 Placement and Hauling Equipment

All equipment shall be serviced away from the paving site to prevent contamination of the mixture. Units that drip fuel, oil, or grease shall be removed from the paved surface until such leakage is corrected.

C2a Asphalt Pavers

Asphalt pavers shall be self-contained, power-propelled units, with an operational vibratory screed, capable of spreading and finishing courses of asphalt plant mix material in widths applicable to the specified typical sections and thicknesses, indicated in the Contract.

The screed or strike-off assembly shall produce a finished surface of the required evenness and texture without tearing, shoving, or gouging. For mainline paving, screed extensions and auger extensions are required if the paving width on either side of the paver is greater than the basic screed unless otherwise directed by the Engineer. Strike-off only extension assemblies are not allowed for mainline wearing course paving, unless directed by the Engineer.

2350.4

Automatic screed control by means of an erected string line, shall only be required when stated in the Contract.

All pavers shall be equipped with an approved automatic screed control. The automatic controls shall include a system of sensor-operated devices which follow reference lines or surfaces on one or both sides of the paver as required. The speed of the paver shall be adjusted to produce the best results.

All mixtures shall be spread without segregation to the cross sections shown in the plans. In general, leveling layers shall be spread by the method producing the best results as approved by the Engineer. The objective is to secure a smooth base of uniform grade and cross section so that subsequent courses will be uniform in thickness. The leveling layer may be spread with a properly equipped paver or with a motor grader equipped with a leveling device, or with other means for controlling the surface elevation of the leveling layer.

All mixtures shall be spread, to the fullest extent practicable, by an asphalt paver. Mixtures may be spread by a motor grader only on areas that are inaccessible to a paver or on driveway entrances and on irregular areas where the quantity of mixture makes it impractical to place with a paver.

On shoulder surfacing and uniform width widening, when the placement width is too narrow for a paver, the mixture in each course shall be spread with an approved mechanical device.

The placement of each course shall be completed over the full width of the section under construction on each day's run unless otherwise directed by the Engineer.

C2b Trucks

Trucks for hauling asphalt mixtures shall have tight, clean, and smooth beds. Mixture shall not be allowed to adhere to the truck beds. Adherence may be prevented by spraying the truck bed with an anti-adhesive agent in accordance with Section 2350.4B. Each truck shall be equipped with a cover of canvas or other suitable material to protect the mixture from weather. The cover shall extend at least 300 mm (**1 foot**) over the sides and be attached to tie-downs unless the truck is furnished with a mechanical or automated covering system which prevents air flow underneath by stretching the cover tightly on the top of or inside the sideboards. The cover shall be used when directed by the Engineer.

C2c Motor Graders

Motor graders shall be self-propelled and have pneumatic-tires with a tread depth of 13 mm (**½ inch**) or less. They shall be equipped with a blade not less than 3 m (**10 feet**) in length and shall have a wheel base of not less than 4.5 m (**15 feet**).

D Treatment of the Surface**D1 Tack Coat**

An asphalt tack coat shall be applied to existing asphalt and concrete surfaces, and to the surface of each course or lift constructed, except for the final course or lift, according to Mn/DOT Standard Specification 2357.

The contact surfaces of all fixed structures and the edge of the in-place mixture in all courses at transverse joints and longitudinal joints shall be given a uniform but not excessive coating of liquid asphalt or emulsified asphalt before placing the adjoining mixture.

E Compaction Operations

After being spread, each course shall be compacted to the required density. The rollers shall, as practicable, be operated continuously so all areas are thoroughly compacted to the required density. When not operating, the rollers shall not stand on the uncompacted mixture or newly rolled pavement having a surface temperature exceeding 60°C (140 ° F). Rolling with steel-wheeled rollers shall be discontinued if it produces excessive crushing or pulverizing of the aggregate or displacement of the mixture.

To prevent adhesion of the mixture to the steel roller wheels, the contact surfaces of the wheels shall be kept properly moistened using water or a water solution containing small quantities of a detergent or other approved material.

To secure a true surface, variations such as depressions or high areas, which may develop during rolling operations, and lean, fat or segregated areas shall be corrected by removing and replacing the material in the defective area. All such corrections shall be accomplished as directed by the Engineer at no expense to the Department.

When mixtures are spread by a motor grader, pneumatic-tired rollers shall compact the mixture simultaneously with the spreading operation.

F Construction Joints

Joints shall be thoroughly compacted to produce a neat, tightly bonded joint that meets surface tolerances. Both transverse and longitudinal joints are subject to specified density requirements. Randomly selected core locations may fall on the joint, in these instances, cores shall be taken tangent to the joint.

F1 Transverse Joints

A transverse joint (full paver width at right angles to the centerline) shall be constructed when mixture placement operations are suspended. The forward end of the freshly laid strip shall be thoroughly compacted by rolling before the mixture has cooled. When work is resumed, the end shall be cut vertically for the full depth of the layer unless a formed edge is constructed as approved by the Engineer.

F2 Longitudinal Joints

2350.4

Longitudinal joints between strips shall be parallel to the centerline. In multiple lift construction, the longitudinal joints between strips in each lift shall be constructed not less than 15 mm (**6 inch**) measured transversely from the longitudinal joints in the previously placed lift. When the wearing course is constructed in an even number of strips, one longitudinal joint shall be on the centerline of the road. When it is constructed in an odd number of strips, the centerline of one strip shall be on the centerline of the road, provided that no joint is located in the wheel path area of a traffic lane.

Longitudinal joints in multiple lift construction over portland cement concrete pavements may be aligned directly over the concrete pavement longitudinal joints at the discretion of the Engineer.

At longitudinal joints formed by placing multiple strips, the adjoining surface being laid shall, after final compacting, be slightly higher (but not to exceed 3 mm (**1/8 inch**)) than the previously placed strip. When constructing a strip adjoining a previously placed strip or a concrete pavement, any fresh mixture that overlaps a previously placed strip or pavement shall be removed (to the longitudinal joint line) before any rolling is done.

After final compaction, all asphalt wearing course surfaces adjacent to concrete pavements shall be flush with the concrete surface, within a tolerance of 3 mm (**1/8 inch**).

After final compaction, all asphalt surfaces adjacent to gutters, manholes, pavement headers, or other fixed structures shall be slightly higher (but not to exceed 6 mm (**1/4 inch**)) than the surface of the structure.

G Asphalt Mixture Production

(FOB Department Trucks)

For asphalt mixture production, the Contractor shall, in addition to the asphalt mixture required on the Project, produce and deliver asphalt mixture to the Department. The mixture shall be the mixture being produced and shall be loaded on Department furnished trucks at the mixing plant at a time agreed on by the Engineer and Contractor. The Engineer will notify the Contractor of the total quantity of mixture desired not less than 2 weeks prior to completion of the wearing course construction. The Engineer will not accept the asphalt mixture if it is inappropriate for the Department's intended use.

H Asphalt Mixtures Measured by the Square Meter (Square Yard) per Specified mm (inch) Thickness

For asphalt mixture measured by the square meter (**square yard**) per specified mm (**inch**) thickness, the Contractor shall certify in writing that the asphalt mixture delivered to the Project meets the appropriate requirements. An approved bituminous paving recommendation is not required for total project quantities less than 215,000 m²/mm (**10,120 square yard per inch**) or 500 metric tons (**550 tons**) of HMA, however,

2350.5

the mixture shall meet the requirements of Table 2350-2 and Table 2350-3. The Department will obtain samples, as determined by the Engineer, to verify percent design air voids, compliance with VMA, and gradation requirements of Table 2350-1. These results will also be used for material acceptance.

**2350.5 MIXTURE QUALITY MANAGEMENT
(CONSTRUCTION)**

A Quality Control (QC)

The Contractor shall provide and maintain a quality control program. A quality control program is defined as all activities, including mix design, process control inspection, sampling and testing, and necessary adjustments in the process that are related to the production of a hot mix asphalt (HMA) pavement which meets the requirements of the specifications.

A1 Contractor Certified Plant Asphalt Mixtures

A1a Certification Procedure

The Contractor shall:

- (1) Complete application form and request for plant inspection.
- (2) Provide a site map of stockpile locations.
- (3) Pass plant and testing facility inspection by having the Plant Inspector and Bituminous Plant Authorized Agent complete and sign the Asphalt Plant Inspection Report (TP 02142-02, TP 02143-02). By signing the Asphalt Plant Inspection Report, the Asphalt Plant Authorized Agent agrees to calibrate and maintain all plant and laboratory equipment within allowable tolerances set forth in these specifications and the Mn/DOT Bituminous Manual.
- (4) Obtain approved mix design recommendations prior to production.

A1b Maintaining Certification

To maintain certification, the plant must produce, test, and document all certified plant asphalt mixtures in accordance with the above requirements on a continuous basis. Continuous basis means all asphalt mixtures supplied from a certified plant to any Department Project with 2350 asphalt mixtures must be sampled and tested in accordance with 2350 requirements. When mixtures are supplied to projects not specifying 2350 requirements for more than 3 working days the supplier shall either:

- (1) Begin testing at least 2 days before producing 2350 Asphalt mixtures for a project with 2350 requirements, or
- (2) Use the first-day sampling rate of four samples during the first 2000 metric tons (2200 ton) as stated in this specification.

The Contractor shall assure the plant certification procedure is performed annually after winter suspension and before producing material

2350.5

for a Project with certified plant requirements. The Contractor shall recertify a plant when it is moved to a new location.

A1c Revocation of Plant Certification

The Department Construction Engineer may revoke certification of an asphalt plant when requirements are not being met or records are falsified. The Department may revoke the Technician Certification for the individual involved.

The Department Bituminous Engineer and Department Contract Administrator will maintain a list of companies who have had their asphalt plant certification revoked.

B Quality Assurance (QA)

The Department will perform QA testing as part of the acceptance process. The Engineer is responsible for QA testing, records, and acceptance. The Engineer will accomplish the QA process by:

- (1) Conducting assurance sampling and testing.
- (2) Observing sampling and tests performed by the QC personnel.
- (3) Monitoring the required QC summary sheets and control charts.
- (4) Taking additional samples at any time and any location during production.
- (5) Verification of calibrations of laboratory testing equipment.
- (6) Communicating Mn/DOT test results to the Contractor's QC personnel in a timely manner.

C Contractor's Quality Control

C1 Personnel Requirements

Along with the proposed mix design data, the Contractor shall submit to the Engineer an organizational chart listing the names and phone numbers of individuals and alternates responsible for mix design, process control administration, and inspection. The Contractor shall also post the organizational chart in the Contractor's test facility.

The Contractor's quality control organization or private testing firm shall have Certified Technicians who have met the requirements on file with the Department's Technical Certification program. Individuals performing process control testing must be certified as a Level I Bituminous Quality Management (QM) Tester. Individuals performing mix design calculations or mix design adjustments must be certified as Level II Bituminous QM Mix Designer. The Contractor shall have a Certified Level II Bituminous QM Mix Designer available to make any necessary process adjustments. The Contractor shall have a minimum of one person per paving operation certified as a Level II Bituminous Street Inspector.

C2 Laboratory Requirements:

The Contractor shall furnish and maintain a laboratory at the plant site or other site as approved by the Engineer. The laboratory shall be furnished with the necessary equipment and supplies for performing Contractor

quality control testing in accordance with Section 5-693.400 in the Mn/DOT Bituminous Manual and these specifications and the latest version of the Mn/DOT Bituminous Manual.

The laboratory shall be equipped with a telephone for use by the Contractor or the Engineer. A fax machine and copy machine shall be available for use by the Contractor or the Engineer at the laboratory site. The laboratory equipment shall meet the requirements listed in section 400 of the Mn/DOT Bituminous Manual and test methods described herein, including extraction capabilities. The laboratory shall be on site, calibrated, and operational prior to the beginning of production.

The Engineer shall be allowed to inspect measuring and testing devices to confirm both calibration and condition. The Contractor shall calibrate and correlate all testing equipment in accordance with the latest version of the Mn/DOT Bituminous Manual.

C3 Sampling and Testing

The Contractor shall use random numbers, as indicated in the Mn/DOT Bituminous Manual 5-693.7 Table A or ASTM D3665; select locations based upon the method described in section 5 of ASTM D3665 so that all QC samples are taken at random locations. The tests for mixture properties shall be conducted on representative portions of the mix, quartered from a larger sample of mixture taken from behind the paver, or alternate approved sampling method on file in the Bituminous Office. The Contractor shall obtain a sample of at least 25 kg (**55 pounds**). This sample may be either split in the field or transported to the test facility by a method to retain heat to facilitate sample quartering procedures. The Contractor shall store and retain Marshall samples and companion samples for the Department for a period of 7 working days. The Contractor shall maintain these split samples in containers (labeled with companion numbers) approved by the Engineer. The Contractor shall perform QC sampling and testing according to the following schedule.

Determine the planned tonnage for each mixture to be produced during the production day. Divide the planned production by 1000. Round the number to the next higher whole number. This number will be the number of production tests, as shown in C3a, required for that mixture. Split the planned production into even increments and select sample locations as described above. During production, mixture volumetric property tests will not be required on the days when mix production is less than 100 metric tons (**110 ton**). However, when mix production is less than 100 metric tons (**110 ton**) per day on successive days, the test will be run when the accumulative tonnage on such days exceeds 100 metric tons (**110 ton**). At the start of production, double the testing frequency for the first two tests for Marshall Bulk Specific Gravity and Maximum Specific Gravity, conduct four tests.

2350.5

For informational purposes only:

On the first day of production, at the time the verification sample is obtained, an additional sample will be collected for hot-cold comparison of mixture properties. Hot-cold comparison testing shall be performed at the rate of one per project or one per stationary plant per year unless otherwise directed by the Engineer.

The hot-cold comparison sample will be split into three representative portions. The Engineer will observe the Contractor testing the sample. One part shall be compacted immediately while still hot (additional heating maybe required to raise the temperature of the sample to compaction temperature). The second part will be allowed to cool to ambient air temperature and then be heated to compaction temperature and compacted. The third part will be allowed to cool to ambient air temperature and then be transported to the District Materials Laboratory where it will be heated to compaction temperature and compacted. From this information a calibration factor will be developed to compare the specific gravity of the hot compacted samples to reheated compacted samples. Each test will involve a minimum of three Marshall specimens. This test may be repeated at the discretion of the Contractor or the Department.

Note: Care must be taken when reheating samples for mixture properties analysis tests. Mix samples should be reheated to 70°C (160°F) to allow splitting of the sample into representative fractions for the various tests. Overheating of the mixture portions to be tested for maximum specific gravity (Rice Test) may result in additional asphalt being absorbed in the aggregate.

C3a Production Tests

When more than one Mn/DOT approved test procedure is available, the Contractor shall select one method at the beginning of the Project (when material is submitted for Mix Design Verification) and use that method for the entire project. The Contractor and Engineer may agree to change test procedures during the construction of the project.

- C3a(1) Asphalt Binder Content, percent
 - (a) Meter Method (Virgin only).....Mn/DOT Bituminous Manual
 - (b) Incinerator Oven ⁽¹⁾Mn/DOT Bituminous Manual Method 1853
 - (c) Extraction Mn/DOT Laboratory Manual Method 1851 or 1852
 - (d) Spot Check (Virgin only) Mn/DOT Bituminous
.....Manual 5-693.848
- (1) Incinerator Oven may not be used when the percentage of Class B material exceeds 50% within the composite blend, unless a correction factor is determined and approved by the District Materials Engineer.
- C3a(2) Marshall Bulk Specific Gravity, G_{mb} (3 specimens)
.....AASHTO T166, Mn/DOT Mod

C3a(3) Maximum Specific Gravity, G_{mm}
 AASHTO T209, Mn/DOT Modified

C3a(4) Production Air Voids (individual and isolated) (calculation)
 Asphalt Institute MS 2

Isolated air voids are calculated using the maximum gravity and the corresponding bulk specific gravity from a single test. Individual air voids are calculated using the moving average maximum specific gravity and the bulk specific gravity from that single test.

C3a(5) Voids Mineral Aggregate (VMA) (calculation)
 Asphalt Institute MS 2

C3a(6) Gradation - Blended Aggregate AASHTO T-11 & T-27
 (all gradations require a - 0.075 mm (#200) wash)

(a) Virgin Aggregate Mixtures - Drum or Screen less Plants

(1) Belt Samples or extracted production samples.

(b) All Other Mixtures:

(1) Field Extraction Mn/DOT Laboratory Manual Method 1854

(2) Hot Bins - Drybatch (Optional)

(3) Incinerator Oven Mn/DOT Laboratory Manual Method 1853
 (Optional) except samples that contain over 50% class B.⁽¹⁾

(4) Extraction Mn/DOT Laboratory Manual Method 1851 or 1852

(Optional)

(1) If the incineration extraction method is used when a mixture contains more than 50% Class B, an aggregate correction factor as approved by the District Materials Engineer must be applied.

Testing to determine the blended aggregate gradation shall be determined every 2000 metric tons (**2,200 ton**), or portion thereof (minimum of one per day), on samples taken at the same time as the required mixture sample for a given increment.

C3b Coarse and Fine Aggregate Crushing

The percentage of crushing of aggregate blends less than 100 percent crushed shall be tested using the methods shown below at the following rates:

(1) Perform two tests per day for each mixture blend for a minimum of two days and then one per day if the test samples meet crushing requirement.

(2) If CAA crushing test results exceed 8 percent of the requirement, take one sample per day and perform one test per week.

(3) If FAA test results exceed 5 percent of the requirement, take one sample per day and perform one test per week.

Crushing counts must be reported on the test summary sheet. Adjustments in target values from the composite blend must be made at the

2350.5

end of each days paving. If the target quantity (percent of - 4 to be crushed) changes due to mixture proportion or composite gradation change, a new target shall be established for the next days paving. Failure to meet requirements shown in Table 2350-2 will result in a reduced payment as shown in Table 2350-5. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within the warning limits.

| | | |
|------|---|---|
| C3b1 | Coarse Aggregate Angularity | ASTM D5821 |
| C3b2 | Fine Aggregate Angularity | ASTM C1252 Method A |
| C3b3 | 4.75 mm (#4) Manufactured Crushed Fines | Calculation) Mn/DOT's Bituminous Manual |
| C3c | Field Tensile Strength Ratio(TSR)ASTM D4867 Mn/DOT Modified | |

Asphalt mixture samples shall be taken at a rate of 1 per 10,000 metric tons (**11,000 ton**) increments for all mixture produced on the project. These samples shall be taken at random as directed by the Engineer. The samples shall be 50 kg (**110 pound**) minimum and split in half. The Department companion of this split shall be labeled with the date, time, project number and approximate cumulative tonnage to date. The Department companion shall be given to the Department Street Inspector or Plant Monitor immediately or delivered to the District Materials Engineer within 48 hours of sampling, as specified by the Engineer. Sampling method shall conform to one of the approved methods on file in the Bituminous Office. These samples may be tested at the discretion of the Engineer. Specimen size shall be 100 mm (**4 inch**).

The following conditions will automatically require a sample to be taken and tested:

- (1) Any individual aggregate stockpile component gradation that deviates more than 10 percent from the original gradation submitted at design as shown in 2350.3. This deviation may be determined from stockpile or extracted gradations conducted by the Contractor or the Engineer.
- (2) Decision of the Engineer.

If the TSR result fails to meet the minimum specified value as shown in Table 2350-2, the Contractor shall be notified immediately by the Department. Action by the Contractor shall be taken to resolve the problem. This action may include addition of anti-stripping agent, addition of hydrated lime, or changes in aggregate components. Any costs associated with these changes shall be borne by the Contractor.

| | | |
|-----|--|--|
| C3d | Aggregate Specific Gravity (Gsb) |AASHTO T84 and T85, Mn/DOT modified |
|-----|--|--|

Samples of all aggregate stockpiles shall be collected on each aggregate used in the production mixture, at a rate of one sample per 10,000 metric tons (**11,000 ton**) mixture produced. These samples shall be taken at

2350.5

random as directed by the Engineer. These representative stockpile samples shall be 40 kg (**90 pound**) of each aggregate component. Each sample shall be split in half. The Department companion shall be labeled with date, time, project number and approximate cumulative tonnage to date. The Department companion shall be given to the Department Street Inspector or Plant Monitor immediately or delivered to the District Materials Engineer within 48 hours of sampling, as specified by the Engineer.

These samples may be tested and if the results deviate beyond the tolerance specified in Table 2350-6, the results will be used for acceptance of specific gravity. Dispute resolution shall follow the procedure on file with the Bituminous Office, however, any mixture placed following notification of new specific gravity values will be based upon Department results unless proven incorrect. The Contractor shall be notified when new specific gravity values become available and what impact this will have on the calculated VMA.

C3e Moisture Content..... Mn/DOT 5-693.950

Provide a mixture with a moisture content not greater than 0.3 percent. The moisture content in the mixture shall be measured behind the paver or alternate approved sampling method on file in the Bituminous Office. Sampling shall be conducted by Contractor and monitored by the Inspector, on the first day of production of each course and then at the discretion of the Engineer. Sampling and testing is suggested when rain on stockpiles exceed more than 5 mm (**0.2 inch**) in a 24 hour period. The sample shall be stored in an airtight container. Microwave testing is prohibited.

HMA that exceeds 0.3% moisture content is unacceptable. The Contractor shall take appropriate action to remove excess water from the mixture. This action may include reducing the production rate, mixing stockpile aggregates prior to placement into the feed bins. A preventative measure could include covering stockpiles.

C3f Asphalt Binder Samples

The Contractor shall sample the first shipment of each type of asphalt binder, then sample at a rate of one per 1,000,000 liters (**250,000 gallons**), sample size shall be 1.0 L (**1 quart**).

All samples shall be taken in accordance with the Mn/DOT Bituminous Manual 5-693.920. Sampling shall be conducted by Contractor and monitored by the Inspector. Promptly submit sample to the Department Materials Laboratory in Maplewood. The Contractor shall record sample information on Asphalt Sample Identification Card.

2350.5

C4 Documentation (Records)

The Contractor shall maintain control charts on an ongoing basis. Reports, records, and diaries developed during the progress of construction activities for the project, shall be filed as directed by the Engineer and will become the property of the Department. The Contractor shall:

1. Number test results in accordance with standard Department procedures and record on forms supplied by the Department.
 2. Facsimile all production test results on test summary sheets to the District Materials Laboratory or to other sites as requested by the Engineer, by 11 AM of the day following production.
- (2a) The following production test results and mixture information shall be included on the Department approved test summary sheet.
1. Percent passing on sieves listed in Table 2350-1.
 2. Coarse and fine aggregate crushing.
 3. Maximum specific gravity (G_{mm}).
 4. Bulk specific gravity (G_{mb}).
 5. Percent asphalt binder content (P_b).
 6. Calculated production air voids (V_a).
 7. Calculated voids in mineral aggregate (VMA).
 8. Composite aggregate specific gravity (G_{sb}) reflecting current proportions.
 9. Stockpile proportions in use at the time of sampling.
 10. Tons where sampled.
 11. Cumulative tons.
 12. Fines to effective asphalt ratio (F/A_e).
- (2b) Submit copies of all failing test results to the Engineer on a daily basis.
3. Provide the Engineer with asphalt delivery invoices on a daily basis.
 4. Provide a daily plant diary to include a description of QC actions taken (adjustment of cold feed percentages, changes in JMFs, etc.) include all changes or adjustments on the test summary sheets.
 5. Provide weekly truck scale spot checks.
 6. Provide a Department approved accounting system for all mixes and provide a daily and final project summary of material quantities and types.
 7. Furnish an automated weigh scale and computer generated weigh ticket. The ticket shall indicate project number, mix designation, pit number, Bituminous Plant Recommendation #, truck identification and tare, net mass, date and time of loading. Any deviations from the minimum information to be provided on the computer generated weigh ticket must be approved by the Engineer in writing.

8. Charts and records for a mixture produced at one plant site shall be continued from contract to contract.

C5 Documentation (Control Charts)

The following data shall be recorded on the standardized control charts:

- (1) Blended aggregate gradation, include sieves shown in Table 2350-1 for specified mixture.
- (2) Percent asphalt binder content
- (3) Maximum specific gravity
- (4) Production air voids
- (5) VMA

Individual test results shall be plotted in black for each test point. A solid black line shall connect points. The moving average for each test variable shall be plotted in red starting with the fourth test. A dashed red line shall connect the points. The Department's assurance and verification test results shall be plotted with green asterisks. Specification JMF and Warning limits shall be indicated on the control charts using a green inked dotted line. The Engineer may waive the plotting of control charts.

C6 Control Limits

The production air voids, VMA and JMF gradation control limits are based upon the minimum specified requirements as shown in Tables 2350-2 & 3. Gradations and Asphalt binder content limits are based upon the current Department approved JMF. Gradation control sieves (subject to Table 2350-5) are shown in Table 2350-1. The mixture production targets are listed on the approved department paving recommendation. Control limits are the target plus or minus the limits shown in Table 2350-4.

**Table 2350-4
Control Limits (N=4)**

| Item | JMF Limits | Warning Limits |
|--|------------|----------------|
| VMA, % | - 1.3 | - 1.0 |
| Production Air Voids, % | ± 1.3 | ± 1.0 |
| Asphalt Binder Content, % | - 0.4 | - 0.3 |
| Sieve - % Passing | | |
| 25.0 mm (1 inch), 19.0 mm (3/4 inch), 12.5 mm (1/2 inch), 9.5 mm (3/8 inch), 4.75mm (#4) | ± 7.0 | ± 6.0 |
| 2.36 mm (# 8) | ± 6.0 | ± 5.0 |
| 0.075 mm (# 200) | ± 2.0 | ± 1.5 |

C7 Warning Bands

Warning Bands are defined as the area between the JMF limits and the warning limits.

2350.5

C8 JMF Adjustment

A request for a JMF adjustment may be made to the Department Bituminous Engineer or District Materials Engineer by the Contractor. The requested change will be reviewed for the Department by a Certified Level II Bituminous QM Mix Designer. If the request meets the design requirements in Section 2350.2G, a revised JMF shall be issued. Each trial mixture design submittal as described in section 2350.3A may have three JMF adjustments per mixture per project without charge. Additional JMF adjustments requested must be accompanied with a \$500 fee per each additional JMF adjustment, payable to the Commissioner of Transportation.

If a JMF change is requested for the 0.075 mm (#200) sieve, the Fines to Effective Asphalt Ratio shall be determined on the moving average from the previous four gradation tests conducted during actual production for the 0.075 mm (#200) sieve. Adjustments to conform to actual production shall not exceed the tolerances specified for the JMF limits. Regardless of such tolerances, the adjusted JMF shall be within the mixture specification gradation design bands in Section 2350.2A2. Should a redesign of the mixture become necessary, a new JMF shall be submitted according to the requirements of the specification. The JMF asphalt content may only be reduced if the production VMA meets or exceeds the minimum VMA design requirement for the mixture being produced.

C9 Corrective Action

When the moving average values trend toward the warning limits, the Contractor shall take corrective action. The corrective action, if any, shall be documented. All tests shall be part of the project files and shall be included in the moving average calculations.

The Contractor shall notify the Engineer whenever the moving average values exceed the warning limits. If two consecutive moving average values exceed the warning limits, the Contractor shall stop production and make adjustments. Production shall only be restarted after notifying the Engineer of the adjustments made. The Contractor shall increase the testing rate to one set of section 2350.5C3a production tests per 450 metric tons (**500 ton**) whenever the moving average exceeds the warning limits. This includes the start-up period after shut down for consecutive averages exceeding the warning limits. The calculation of the moving average for the tests listed in 2350.5C3a shall not be calculated until the fourth test after the required stop in production.

Failure to stop production and make adjustments when required shall subject all mixture produced from the tonnage point the mixture exceeded the warning limit to the tonnage point when the moving average is back within the warning limits to be considered unsatisfactory. Reduced payment for unsatisfactory mixtures will be applied in accordance with Table 2350-5.

If the process adjustment improves the property in question such that the moving average after four additional tests is within the warning limits, the Contractor may continue production with no reduction in payment. If the adjustment does not improve the properties and the moving average after four additional tests stays in the warning bands, the mixture will be considered unsatisfactory. Reduced payment for unsatisfactory mixtures will be applied starting from the plant tonnage the mixture exceeded the warning limit to the tonnage when the moving average is back within the warning limits in accordance with the following Table.

**Table 2350-5
Payment Schedule**

| Item | % Payment ⁽¹⁾ |
|---|--------------------------|
| Coarse and Fine Aggregate Crushing ⁽²⁾ | 95 |
| Gradation | 90 |
| VMA | 85 |
| Asphalt Binder Content | 85 |
| Production Air Voids (individual) | 70 |

(1) Lowest Single Payment applies

(2) Corrective action provision does not apply, any results below minimum specified subject to this reduced payment.

C10 Failing Materials

If the moving average values exceed the JMF limits, the Contractor shall stop production and make adjustments. Production shall only be restarted after notifying the Engineer of the adjustments made. The calculation of the moving average shall continue after the stop in production.

When the total production of a mixture type for the entire project requires less than four tests, single data points shall be compared to the square root of n times the warning limit, where n is the number of production tests. If the test results exceed these limits, the corrective action outlined previously will apply or if necessary, reduced payment as outlined below.

When the Contractor's testing data fails to meet specified tolerances, quality assurance and verification data shall be used in-place of the Contractor's data to determine the appropriate payment factor.

C10a Moving Average Failure - Production Air Voids

Mixture placed with the individual production air voids moving average of four, exceeding the JMF limits will be considered unacceptable and shall be removed and replaced by the Contractor at the Contractor's expense. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all test results beyond the warning limits which contributed to the moving average value that exceeded the JMF limit, through the sampling

2350.5

point when the test result is back within the warning limits. If the Engineer decides to leave the mixture in place because of special circumstances, the mixture will be paid for at 50 percent of the contract bid price.

C10b Moving Average Failure - Percent Asphalt Binder Content, VMA, and Gradation

For properties including asphalt binder content, VMA, and Gradation, where the moving average of four exceeds the JMF limits, payment will be at 75 percent of the contract bid price for mixture provided the mixture is allowed to remain in place by the Engineer.

Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all test results beyond the warning limits which contributed to the moving average value that exceeded the JMF limit, through the sampling point when the test result is back within the warning limits.

C10c Individual Failure - Production Air Voids, Percent Asphalt Binder, and VMA

If the individual Quality Control tests for individual Air Voids, percent asphalt binder content, and/or voids in the mineral aggregate (VMA) exceed twice the warning limits and the results are verified by QA tests, the material is considered unsatisfactory or unacceptable. An investigation will be conducted to determine the extent of the problem and the amount of any price adjustments for unsatisfactory or unacceptable mixtures. Reduced payment as outlined in Table 2350-5 shall apply to all mixture represented by those results. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within the warning limits.

C10d Individual Failure - Gradation

If the individual gradation test exceeds twice the warning limits and is outside the gradation bands listed in Table 2350-1, and is verified by QA tests, the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2350-5 shall apply to all mixture represented by those results.

Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within the warning limits.

C10e Coarse and Fine Aggregate Crushing Failure

If any test result for Coarse Aggregate Angularity, Fine Aggregate Angularity or - 4.75 mm (- #4) calculated crushing fail to meet minimum requirements in table 2350-2, and the result is verified by Department tests, all material placed is subject to reduced payment as provide in Table 2350-5.

Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within the warning limits.

D Quality Assurance (QA)

The Engineer will periodically witness the sampling and testing being performed by the Contractor. If the Engineer observes that the sampling and quality control tests are not being performed in accordance with the applicable test procedures, the Engineer may stop production until corrective action is taken. The Engineer will notify the Contractor of observed deficiencies promptly, both verbally and in writing. The Engineer will document all witnessed samples and tests. The Engineer may sample materials or final density at any time to determine quality levels. A split from these samples will be provided to the Contractor for testing. Results from these tests must be included in the control charts.

All testing and data analysis shall be performed by the Certified Level I Bituminous Quality Management (QM) Technician. Certification shall be in accordance with the Mn/DOT Technical Certification Program. The Department shall post a chart giving the names and telephone numbers for the personnel responsible for the assurance program.

The Engineer shall calibrate and correlate all laboratory testing equipment in accordance with the latest version of the Mn/DOT Bituminous Manual.

2350.5

**Table 2350-6
Test Result Tolerances ***

| Item | Allowable Difference | |
|--|--------------------------------|----------------|
| Marshall Bulk Specific Gravity (G_{mb}) | 0.030 | |
| Mixture Maximum Specific Gravity (G_{mm}) | 0.019 | |
| Fine Aggregate Angularity, uncompacted voids (U) % | 1.0 | |
| Coarse Aggregate Angularity, % fractured faces (%P) | 15 | |
| Aggregate combined blend Specific Gravity (G_{sb}) | 0.020 | |
| Tensile Strength Ratio (TSR) % | Mn/DOT Verification Min =65 | |
| Asphalt Binder Content | | |
| Meter Method, % | 0.2 | |
| Spot Check Method, % | 0.2 | |
| Chemical Extraction Methods, % | 0.6 | |
| Incinerator Oven, % | Same Oven | Different Oven |
| | 0.2 | 0.3 |
| Chemical vs. Meter, Spot Check, or Incinerator methods | 0.4 | |
| Gradation Sieve % passing | | |
| 25.0 mm (1 inch), 19.0 mm (3/4 inch), 12.5 mm (1/2 inch), 9.5 mm (3/8 inch) | 6.0 | |
| 4.75 mm (#4) | 5.0 | |
| 2.36 mm (#8) | 4.0 | |
| 0.075 mm (#200) | 2.0 | |

* Test tolerances listed are for individual test comparisons.

E Verification Testing

Verification testing shall be performed on one set of production tests 2350.5C3a, C3b on a daily basis. A verification sample and verification companion will be obtained on a daily basis.

The verification sample will be used to verify the requirements listed in Table 2350-1 through Table 2350-3, and asphalt content as specified by the mixture recommendation and shall meet the tolerances listed in Table 2350-6. These include the mixture properties of G_{mm} (mixture max gravity), G_{mb} (mixture bulk gravity), asphalt binder content, VMA (calculated) Coarse and Fine Aggregate crushing, and gradation. These do not include the aggregate bulk specific gravity G_{sb} , fines to effective asphalt, or the tensile strength ratio TSR. Asphalt binder content and gradation must be determined by either extraction method 2350.5C3a(1)b or 2350.5C3a(1)c. Asphalt content from the verification test result must be used to determine VMA.

Test results will be made available to the Contractor within two Mn/DOT working days, from the time the sample is obtained by the District Materials Laboratory, for G_{mm} mixture max gravity, G_{mb} mixture

2350.5

bulk gravity, air voids (calculated), asphalt binder content, VMA (calculated). Gradation and crushing results will be provided to the Contractor within three Mn/DOT working days.

A verification sample is a sample which is sampled and tested by Mn/DOT to assure compliance of the Contractor's Quality Control program. A verification companion is a companion sample, to Mn/DOT's verification sample, provided to the Contractor. The Contractor is required to test this verification companion sample. These results shall be used as part of the QC program.

The verification process is intended to identify potential sampling and/or testing discrepancies between the Contractor and the Department. In the event verification of the aforementioned mixture properties is unsuccessful, an investigation into the source of problems will commence immediately. Until the source of error is found, the Department's test results will be used for acceptance. If the source of problem(s) is not found within 48 hours of determination that verification is not successful, the Contractor shall cease mixture production and placement until the problem is identified and resolved. The District Materials Laboratories will not run accelerated testing indefinitely. All efforts must be made to determine the source of the lack of proper verification of mixture properties. This process is available in flow chart format in the Bituminous Office.

E1 Testing Methodology Verification

E1a Verification and Companion test results meet tolerance

If the Department's verification test results and the Contractor's verification companion test results meet the specified tolerances shown in Table 2350-6, the testing methodology has successfully been verified. Proceed to the Sampling methodology verification procedure.

E1b Verification and Companion test results do not meet tolerance

If the Department's verification test results and the Contractor's verification companion test results are not within the specified tolerances listed in Table 2350-6, a determination of validity is required {E1b(1)}. (Retests of the first material shall be conducted by Department and Contractor before proceeding to E1b(1)).

E1b(1) Verification validation

When tolerances are not met, the Department will collect the previously saved QA sample and test accordingly.

E1b(2) Verification validation (QA check meets tolerance)

If the test results from the QA sample as compared to the QC split companion (which was already performed by the Contractor) meets the tolerances specified, the verification test is considered an exception and the QA companion result is acceptable for verification of the

2350.6

Contractor's QC testing methodology. Proceed to the Sampling methodology verification procedure.

E1b(3) Verification validation (QA check does not meet tolerance)

If the test result from the QA sample does not meet the tolerance specified, the original verification test is validated and the Department will continue to test the remaining QA samples until they meet the tolerance or remaining samples are all tested, whichever comes first. Acceptance for materials supplied to date, since last acceptable verification, will be made based upon the Department test results. An investigation shall commence immediately to determine the cause of this difference. Testing equipment, procedures, and personnel will be reviewed to determine the source of the problem.

E2 Sampling Methodology Verification

To verify the sampling methodology, the Department test results described in E1a or E1b(2) must be compared to the Contractor's most recent moving average QC test results. Validation of sampling methodology is conducted after successful completion of testing methodology verification.

E2a Verification and QC moving average meet tolerance.

If the Department verification test results in E1a or verification validation test results in (E1b(2)), as compared to the Contractor's most recent moving average QC test results, are within 1.5 times the tolerances listed in Table 2350-6, the sampling methodology is successfully verified. Acceptance of material will be based on the Contractor's QC data.

E2b Verification and QC moving average do not meet tolerance.

If the Department verification test results in E1a or verification validation test results in (E1b(2)), as compared to the Contractor's most recent moving average QC test results, are not within 1.5 times the tolerances listed in Table 2350-6, a determination of validity is required E2b(1).

E2b(1) Verification Validation

When tolerances are not met, the Department will collect another verification sample from subsequent production. A determination will be made whether there has been poor sampling methodology or whether the test result is an exception.

E2b(2) Verification Validation

(Second verification meets tolerance vs moving average)

If the second verification sample tested meets the 1.5 times tolerance specified, the first verification sample can be considered an exception. Acceptance of material will be based upon the Contractor's QC data.

E2b(3) Verification Validation (Second verification does not meet tolerance)

2350.6

If the second verification sample tested fails to meet 1.5 times the tolerance with the Contractor's moving average, then the sampling methodology is suspect. Acceptance of material will be based upon the Department's verification test results. This will remain in effect until acceptable tolerance between the Contractor's moving average and the Department verification can be reestablished. If reestablishment of test results is not achieved within 48 hours, the Contractor shall cease mixture production and placement until the problem is resolved. Investigation of sampling procedures, equipment, and personnel will commence immediately.

If verification test results that are used for acceptance indicate failure to comply with volumetric or densification properties, the material placed will be subject to penalties or removal and replacement as described in Table 2350-5 and 2350-10

2350.6 PAVEMENT DENSITY

A General

All pavements will be constructed in accordance with the Maximum Density Method unless otherwise specified. Compaction of variable thickness leveling layers (minimum thickness less than 40 mm (**1.5 inches**)), layers less than 40 mm (**1.5 inches**), thin lift leveling, wedging layers, patching layers, driveways, areas which can not be compacted with standard highway construction equipment and non-traffic areas (excluding shoulders without rolled in rumble strips) will be accomplished according to the Ordinary Compaction Procedure, Subsection 2350.6C.

B Maximum Density Method

All courses or layers of plant mixed asphalt mixtures for which the Maximum Density Method is used shall be compacted to a density not less than the percentage shown in the Table of Required Density, Table 2350-8, for the applicable mixture and course.

B1 Maximum Density Determination.

The Density requirements listed in Table 2350-8 are percent of maximum specific gravity (G_{mm}) based on the individual lot. The Maximum specific gravity value used to calculate the percentage density for the lot shall be the average value obtained from the maximum gravity results from production tests taken during that days paving. If a new job mix formula is established, a new maximum specific gravity reflecting the new job mix formula will be used for maximum density determination.

B2 Pavement Density Determination.

The density of each lot shall be expressed as a percentage of the maximum specific gravity ($\% G_{mm}$) obtained by dividing the average bulk specific gravity for the lot by the maximum specific gravity multiplied by 100, (maximum specific gravity basis is the average G_{mm} of QC tests done on the day that the individual lot was paved). Determination of the bulk specific gravity of the cores shall be in accordance with AASHTO T-166,

2350.6

Mn/DOT modified. For coarse graded mixtures the Engineer may require determination of bulk specific gravity of the cores be in accordance with ASTM D1188 , Mn/DOT modified. The determination of coarse and fine graded mixtures will be based on the percentage of material passing the 4.75 mm(#4) sieve as defined in Table 2350-3.

Compaction operations shall be completed within 8 hours of mixture placement and before core samples are obtained for density determination. Only pneumatic tired or static steel rollers are permitted for any compactive effort performed between 6 and 8 hours after mixture placement.

Compacted mixtures represented by samples or tests having deficient densities shall not be re-rolled. The Contractor shall not operate below the specified minimum density on a continuing basis. A continuing basis shall be defined as all lots in a days production failing to meet minimum density or more than 50% of lots on multiple days which fail to meet minimum density requirements. Production shall be stopped until the source of the problem is determined and corrective action is taken to bring the work into compliance with specifications.

Divide the days production into equal lots as shown in Table 2350-7 and obtain three cores in each lot. Two cores will be taken from random locations selected by the Engineer. The third core, a companion core, shall be taken 0.3 meters (**1 foot**) longitudinally from either of the first two cores. The companion cores shall be given to the Department Street Inspector upon completion of coring and sawing. The random locations will be determined by the Engineer using statistically derived stratified random number Tables. These will also be used for partial lots. Cores will not be taken within 0.3 meter (**1 foot**) of any unsupported edge. The Contractor shall be responsible for maintenance of traffic, coring, patching the core holes, and sawing the cores if necessary to the proper thickness prior to density testing.

If the companion cores from two consecutive days paving meet specified tolerances for bulk specific gravity, as shown in Table 2350-6, the companion core rate may be reduced to thirty percent of the lots, rounded to the nearest whole number. This reduction shall be subject to approval by the Engineer. If any companion cores fail to meet tolerance on subsequent days, the core rate shall revert to the original rate of one companion per lot.

Table 2350 - 7
Lot Determination

| Daily Production | | Lots |
|------------------|---------------|------|
| Metric Ton | English(ton) | |
| 0 - 545 | (0 - 600) | 1 |
| 546 - 910 | (601 - 1000) | 2 |
| 911 - 1455 | (1001 - 1600) | 3 |
| 1456 - 3275 | (1601 - 3600) | 4 |
| 3276 - 4545 | (3601 - 5000) | 5 |
| 4546 + | (500 +) | 6 |

B3 Core Testing

Cores will be taken by the Contractor and observed by the Department. The Contractor will cut pavement samples from the completed work with power equipment, and restore the surface by the end of the next working day with new, well compacted mixture without additional compensation. Failure to restore the surface within 24 hours of coring shall subject the Contractor to a fine of \$100 per working day, per lot, until the core holes are restored. Cores shall be cut using a 100mm (**4 inch**) minimum outer diameter coring device. All samples shall be marked with the lot number and core number or letter. The cores shall be transported to the laboratory as soon as possible to prevent damage due to improper handling or exposure to heat. These companion cores may be tested by the Inspector on Department scales or transported to the Department's Field Laboratory or District Materials Laboratory.

Measure each core three times for thickness prior to saw cutting, report the average lift thickness on the core sheet. These average thickness will contribute to thickness compliance as described in section 2350.7A

If the Department companion core test result for bulk specific gravity (G_{mb}) deviates beyond the allowable tolerance of 0.030, substitute Department companion result for Contractor's core result and then average the Department result with the non-companion result for the lot density acceptance.

If the G_{mb} tolerance fails in more than 2 lots in a day of either consistently high or low differences between the companion cores then an investigation to determine the source of errors shall be conducted. Companion cores samples shall be increased to two per lot and tested until investigation is complete and tolerances are met.

The Engineer may allow recoring of a sample only when the core has been damaged through no fault of the Contractor, either during the coring process or in transit to the laboratory.

B4 Required Density

2350.6

**Table 2350-8
Required Density**

| Percent Density | | |
|------------------------------|---------------------|---------------------|
| Location | HV mixtures | MV and LV mixtures |
| Traffic Lanes ⁽¹⁾ | 91.5 ⁽²⁾ | 91.5 ⁽²⁾ |

⁽¹⁾ Includes Parking Lanes as determined by the Engineer.

⁽²⁾ Minimum reduced by one percent for the first lift constructed on aggregate base, or cold recycled base courses and first lift of an overlay on a roadway with a 6.35 metric ton (7 ton) or less spring load restriction.

Minimum reduced by one percent on the first lift constructed over pcc pavements that have 30% or more: faulted joints & cracks and/or contain mid panel cracks. Where faults and cracks are defined as follows:

fault > 6.35 mm (0.25 inch)

mid panel cracks are > 2 mm (1/16 inch) width and 0.6 m (2 feet) or more in length.

B5 Maximum Density Acceptance and Payment Schedule.

Density of compacted mixture shall be accepted by pavement cores on a lot basis. Core locations will be determined by the Engineer. Cores shall be tested by the Contractor and verified by the Department. Density determination will be made by the end of the next working day after placement and compaction. If multiple layers are placed in a single day, cores shall be sawn and separated for each layer, tested and reported by the end of the next working day.

The Contractor's cores will be used for acceptance if the determined bulk specific gravity G_{mb} from AASHTO T-166, Mn/DOT modified dated 11/24/99 or ASTM D1188 is within ± 0.030 of the state companion G_{mb} value.

When the density of a lot, of compacted mixture, is less than the specified minimum, payment will be made at an adjusted price as specified in Table 2350-10:

Table 2350-9-Blank

Table 2350-10
Payment Schedule for Maximum Density ⁽¹⁾
(Wear and Non wear)

| % Density ⁽²⁾ HV, MV, & LV Mixtures | Payment Factor (% Contract Price) |
|---|--------------------------------------|
| 93.1 and above | 104 ⁽³⁾ |
| 92.6-93.0 | 102 ⁽³⁾ |
| 91.5-92.5 | 100 |
| 90.5-91.4 | 98 |
| 90.0-90.4 | 95 |
| 89.5-89.9 | 91 |
| 89.0-89.4 | 85 |
| 88.5-88.9 | 70 |
| Less than 88.4 | (4) |

- (1) Incentive payment is excluded when the minimum density requirement has been reduced by one percent for the first lift constructed on aggregate base, cold recycled base courses, first lift of an overlay on a roadway with a 6.35 metric ton (7 ton) or less spring load restriction or on the first lift constructed over pcc pavements that have 30% or more faulted joints & cracks and/or contain mid panel cracks.
- (2) In calculating the percent of maximum specific gravity, report to the nearest tenth.
- (3) The payment in this portion of the specification shall only apply if the individual air voids, as determined from mixture production test (2350.5C3a(4)) that represents the tonnage placed at that specific cores location, are no less than - 0.5 percent from the target value.
- (4) Areas of asphalt pavement shall be removed and replaced by the Contractor at their expense with mixture of the specified density and, when acceptably replaced, will be paid for at the contract unit price per ton for the original material; or the Engineer may permit the unacceptable material to remain in place with a 50 percent payment factor. The limits of the area to be removed will be determined by cored samples. These cored samples shall be taken by the Contractor as directed by the Engineer. The densities shall be determined at 15 m (50 foot) increments both ahead and back of the point of unacceptable density, and at the same offset as the original core site. If these tests indicate unacceptable density, 15 m (50 foot) incremental testing shall continue until a point of acceptable density is found, which is a maximum of 3.0 percent or less below the target minimum density. If the 15 m (50 foot) incremental testing extends into a previously accepted lot, removal of the unacceptable material will

2350.6

be required; however, the results of these tests shall not be used to recalculate the previously accepted lot density. If a portion of the lot density is determined to be within the limits of acceptability, that area shall be compensated at the level shown in Tables 2350-10. All costs incurred from additional coring and testing, resulting from unacceptable material will be paid by the Contractor. The unacceptable pavement area is computed as the product of the longitudinal limits so determined by the 15 meter (**50 foot**) cores and the full width of the paver pass, laying in the traffic lane or lanes. Shoulders shall be exempt from this calculation, unless density failure occurred in the shoulder area.

C Ordinary Compaction Method

This compaction method shall not be used on mainline, ramp, loop paving, or unless otherwise designated. A control strip shall be used to establish a rolling pattern. This shall be used by the Contractor for the compaction of the asphalt mixture for the layer on which the control strip is constructed, or until a new control strip is constructed. The control strip requirement may be waived by the Engineer in small localized areas or other areas not conducive to its establishment. A control strip shall be constructed at the beginning of the work on each lift of each course. Each control strip shall have an area of at least 330 m² (**395 square yards**) and shall be of the same thickness as the lift it represents. The subgrade or pavement course upon which a control strip is to be constructed shall have the prior approval of the Engineer. The control strips shall remain in place and become part of the completed work.

The materials used in the construction of the control strips shall conform to the specified requirements for the course. The materials used in the control strip shall be from the same source and of the same type as the materials used in the remainder of the course that the control strip represents.

The equipment used in the construction of the control strips shall be approved by the Engineer and shall be the same type and mass used on the remainder of the pavement course represented by the control strip. A minimum of two rollers shall be required. A rolling pattern shall be established for each roller. A pneumatic-tired roller shall be available for compaction operations within 24 hours after request by the Engineer. The final rolling shall be performed with a tandem steel-wheeled roller. Areas that are inaccessible to the conventional type rolling equipment shall be compacted to the required density by using trench rollers or mechanical tampers.

Construction of the control strips will be as directed by the Engineer. Compaction shall commence as soon as possible after the mixture has been spread to the desired thickness and shall continue until no appreciable increase in density can be obtained by additional roller's coverages. Densities will be determined by means of a portable nuclear testing device or suitable approved alternate. The Contractor shall furnish documentation of the growth curve to the Engineer.

2350.6

To determine when no appreciable increase in density can be obtained, two test points shall be established in the control strip on a random basis and the density at each point shall be measured by a portable nuclear device or suitable approved alternate after each roller passes. Rolling shall be suspended when testing shows either a decline of more than 2% of the maximum specific gravity or when additional roller passes fail to increase the density.

After said testing is accomplished, rolling on the remainder of that course shall be done in accordance with the pattern developed in the test strip for that roller. A separate rolling pattern and time interval shall be established for each roller. A new control strip shall be ordered by the Engineer when:

- (a) A change in the JMF is made, or
- (b) A change in the source of material is made or a change in the material from the same source is observed.

A new control strip may be ordered by the Engineer or requested by the Contractor when:

- (a) Ten days of production have been accepted without construction of a new control strip, or
- (b) There are other reasons to believe that a control strip density is not representative of the asphalt mixture being placed.

The nuclear testing device or approved alternate shall be furnished and operated by the Contractor. The furnishing of the testing device and the operator will be considered incidental to the furnishing and placement of the asphalt mixture and shall not be compensated for separately. The device shall be calibrated according to procedures described in the Mn/DOT Bituminous Manual.

Each course shall be uniformly compacted until there is no further evidence of consolidation and all roller marks are eliminated. When this method is employed, and the quantity of mixture placed by the paver exceeds 100 metric tons (**110 ton**) per hour, at least two rollers are required for compacting the mixture placed by each paver.

C1 Rollers

The following requirements for rollers apply only when compaction is obtained by the ordinary compaction method.

C2 Steel-Wheeled Rollers

Steel-wheeled rollers shall be self-propelled and have a minimum total mass of 7.3 metric tons (**8 ton**), or as otherwise specified in the Contract. When vibratory rollers are used, they shall produce 45 kN per meter (**3085 pound per foot**) of width. The frequency should be at least 2400 vpm. The roller shall be capable of reversing without backlash and shall be equipped with spray attachments for moistening all rollers on both sets of wheels.

C3 Pneumatic-Tired Rollers

2350.6

The pneumatic-tired roller shall have a compacting width of 1.5 m (5 feet) or more. It shall be so constructed that the gross wheel load force shall be a minimum of 13 kN (3000 pounds) per wheel for LV and MV mixtures and 22 kN (5,000 pounds) per wheel for HV mixtures and can be varied as directed by the Engineer. The tire arrangement shall be such that full compaction will be obtained over the full width with each pass of the roller.

The roller may be self propelled or provided with suitable tractive equipment, unless otherwise specified in the contract. If more than one roller is propelled by a single tractive unit, then that combination will be counted as a single roller unit.

C4 Trench Rollers

Trench rollers shall be self propelled and have a mass of not less than 4400 kg per meter (2960 pound per foot) of width.

C5 Mixture Temperature Controls

If compaction is obtained by the ordinary compaction method, the minimum laydown temperature in all courses (as measured behind the paver or spreading machine) of the asphalt mixture shall be in accordance with the temperature requirements of Table 2350 - 11.

**Table 2350 -11
Mixture Temperature Control**

| Air Temperature °C (°F) | Compacted Mat Thickness, mm ^(A) (inch) | | | |
|----------------------------|---|-----------------------------|-------------------|---------------------------------|
| | 25 mm (1 inch) | 40 mm (1-1/2 inch) | 50 mm (2 inch) | 75 mm (3 inch) or greater |
| +0-5 (32-40) | -- | 129 ^(B) (265) | 124 (255) | 121 (250) |
| + 6-10 (41-50) | 130 ^(B) (270) | 127 (260) | 121 (250) | 118 (245) |
| + 11-15 (51-60) | 127 ^(B) (260) | 124 (255) | 118 (245) | 115 (240) |
| + 16-21 (61-70) | 121 ^(B) (250) | 118 (245) | 115 (240) | 113 (235) |
| + 22-27 (71-80) | 118 (245) | 115 (240) | 113 (235) | 113 (235) |
| + 28-32 (81-90) | 113 (235) | 110 (230) | 110 (230) | 110 (230) |
| + 33 (91+) | 110 (230) | 110 (230) | 110 (230) | 107 (225) |

(A) Based on approved or specified compacted lift thickness.

(B) A minimum of one pneumatic-tire roller shall be used for intermediate rolling unless otherwise directed by the Engineer.

The Engineer may specify or modify in writing (with concurrence from the Department Bituminous Engineer) a minimum laydown temperature.

2350.7 THICKNESS AND SURFACE SMOOTHNESS REQUIREMENTS**A Thickness**

After compaction the thickness of each course shall be within a tolerance of 6 mm (**1/4 inch**) of the thickness shown in the Plans, except that, if automatic grade controls are used, this thickness requirement will not apply to the first course placed. This thickness requirement will not apply to a leveling course whether or not automatic grade controls are required. Any part of any course that is constructed to less than the minimum required thickness may be removed and replaced at the discretion of the Engineer.

On that portion of any course constructed to more than the maximum permissible thickness, the materials used in the excess mixture above that required to construct that portion of the course to the Plan thickness plus 6 mm (**1/4 inch**) will be excluded from the pay quantities and may require removal and replacement at the discretion of the Engineer.

Cores taken for density determination shall be measured for thickness also. Each core shall be measured 3 times for thickness prior to sawing.

Report the average of these three measurements. Each lot's average core thickness shall be documented and submitted to the Engineer. If the average of the two Contractor cores exceed the specified tolerance, an additional two cores may be taken in the lot in question. The average of all core thickness measurements per course will be used to determine compliance with thickness specifications.

B Surface Requirements

After compaction, the finished surface of each course shall be reasonably free of open and torn sections and shall be smooth and true to the grade and cross section shown on the Plans with the following tolerances:

- (a) Where a leveling course is specified, it shall be constructed to within a tolerance of 15 mm (**1/2 inch**) of the elevations and grades established by the Engineer. This requirement shall also apply to the first course placed other than leveling when automatic controls are used.
- (b) The surface of the Non wear course and wearing course shall show no variation greater than 3 mm (**1/8 inch**) from the edge of a 3 m (**10 foot**) straightedge laid parallel to or at right angles to the centerline. Shoulder surfacing and surfacing on temporary connections and by-passes shall show no variations greater than 6 mm (**1/4 inch**) from the edge of a 3 m (**10 foot**) straightedge laid parallel to the centerline.
- (c) The transverse slope of the surface of each course, exclusive of the shoulder wearing course, shall not vary from the slope shown in the Plans by more than 0.4 percent.

2350.7

- (d) The distance between the edge of each course and the established centerline shall be no less than the Plan distance nor more than 75 mm (**3 inch**) greater than the Plan distance. In addition, the edge alignment of the wearing course on tangent sections and on curve sections of 3 degrees or less shall not deviate from the established alignment by more than 25 mm (**1 inch**) in any 7.5 m (**25 foot**) section.

Any material placed outside the above described limitations shall be removed after being cut or sawed at no expense to the Department.

C Pavement Smoothness:

C1 General

Pavement smoothness will be evaluated on the final mainline pavement surface. The following Table shows pavement surfaces which are excluded from profilograph testing but subject to 2350.7B surface requirements.

**Table 2350-12
Profilograph Testing Exclusions**

| |
|--|
| Pavement Surfaces Excluded From Profilograph Testing |
| Ramps, Loops, Climbing Lanes |
| Side Streets, Side Connections |
| Turn Lanes, Storage Lanes, Crossovers, By-pass Lanes |
| Shoulders |
| Acceleration, Deceleration Lanes |
| Intersections constructed under traffic |
| Sections less than 15.24 m (50 feet) in length |
| Mainline paving where the posted speed is less than or equal to 70 km/h (45 miles per hour) |
| Single lift overlays over concrete. |

C1 A Smoothness Requirements

Pavement smoothness requirements will be evaluated by Table 2350-13A, 2350-13B, or 2350-13C in accordance with the following unless otherwise modified.

**Schedule for Identification of Pavement Sections
Construction Type**

| | Table |
|---|--------------|
| New construction with minimum of 3 lifts..... | 2350-13 A |
| Overlay with a minimum of 3 lifts 40 mm (1.5 inch) minimum lift thickness..... | 2350-13 A |
| Construction with 8' min shoulder separation between C&G and driving lanes min 3 lifts. | 2350-13 A |
| Single lift overlays 40mm (1.5 inch) or more in thickness that have profile milling of the original pavement. | 2350-13 B |
| New construction with minimum 2 lifts. | 2350-13B |
| Construction with curb and gutter adjacent to at least one driving lane | 2350-13 B |
| Single lift mill (mainline and shoulder) and fill overlays | 2350-13B |
| Two- lift overlays 40 mm (1.5 inch) minimum lift thickness on an unmilled surface | 2350-13 B |
| Winter carry-over wearing course | 2350-13 B |
| Reclaim with 2 lifts | 2350-13 B |
| Uniform mill with 2 lifts | 2350-13 B |
| BOC with PSR(2.7-3.2) and 2 lifts..... | 2350-13 B |
| New construction with 1 lift..... | 2350-13 C |
| Single lift overlays on an unmilled surface. | 2350-13 C |
| Construction adjacent to existing pavement..... | 2350-13 C |
| BOC with 2 lifts and PSR<2.7 | 2350-13 C |

Note: Profile Milling: Profile milling shall consist of (1) Using a grade leveling ski control or traveling string line not less than 30 feet in length attached to the milling machine and operating parallel to its line of travel or (2) Using an erected string line, offset from and parallel to the pavement edge on one or both sides, and set parallel to the established grade for the pavement surface.

Uniform Milling: Uniform milling shall consist of specified depth milling.

C2 Measurement

Smoothness will be measured with a 7.62 m (**25 foot**) California type profilograph, which produces a profilogram (profile trace of the surface tested). One pass will be made in each lane, 2.74 m (**9 feet**) from centerline. Each lane will be tested and evaluated separately. The Engineer will determine the length in kilometers (miles) for each mainline

2350.7

traffic lane. The profilograph will be operated at a speed no greater than a normal walk, no greater than 6 km/hr (**4 miles per hour**). Motive power may be provided manually or by the use of a propulsion unit approved by the Engineer.

C3 Profilograph testing

The Contractor will furnish a properly calibrated and documented, 7.62 m (**25 foot**) California type profilograph. The profilograph shall be equipped with automatic data reduction capabilities unless otherwise authorized by the Engineer. Calibration documentation shall be provided to the Engineer on the first day the profilograph is used on the project. User selected profilograph settings are on file in the Bituminous Office. The Contractor will furnish a competent operator, trained in the operation and evaluation of the 7.62 m (**25 foot**) California profilograph..

All objects and foreign material on the pavement surface will be removed by the Contractor prior to testing.

The pavement surface will be divided into sections which represent continuous placement. A section will terminate 7.62m (**25 feet**) before a ridge approach panel, bridge surface, manhole or similar interruption. A day's work joint will be included in the trace with no special consideration. A section will be separated into segments of 0.1 km (**0.1 mile**) A segment will be in only one traffic lane.

A profilogram will be made for each segment of 15.24 m (**50 feet**) or more. The profilogram will include the 7.62 m (**25 feet**) at the ends of the section only when the Contractor is responsible for the adjoining surface.

End of run areas not included in the profilograph trace and any sections of pavement less than 15.24 m (**50 feet**) in length shall be checked longitudinally with a 3.028 m (**10 foot**) straight edge and the surface shall not deviate from a straight line by more than 3 mm in 3.028 m (**1/8 inch in 10 feet**).

The profile trace and index for each segment of pavement must be furnished to the Engineer within 48 hours after each days run. Identification of all bumps and dips, with signature of the Operator shall be included with the submitted trace.

For each day's run, an evaluation will be submitted to the Engineer within five days after pavement placement. The evaluation submitted shall include identification of segments which may qualify for less than 100 percent payment, segments that qualify for incentive payment and segments to be corrected.

The Contractor will be responsible for all traffic control associated with the smoothness testing.

Any portion of the project may be retested if the Engineer determines that the Contractor's test results are in question. If results are found to be inaccurate, the Contractor will be charged at a rate of \$155.34 per lane km (\$250 per lane mile) that is retested, with a minimum charge of \$500.00. If the results are found to be accurate, the Department will pay the

Contractor at a rate of \$155.34 per lane km (**\$250 per lane mile**) that is retested, with a minimum charge of \$500.00.

C4 Profile Index

The profilograph trace will be evaluated by the Contractor for the profile index (PI) in accordance with California Method 526 on file with the Department Bituminous Engineer. The original trace shall be provided to the Engineer for verification of the Contractor's evaluation.

A profile index shall be calculated for each segment. The index will be determined by summing the vertical deviations outside a 5 mm (**0.2 inch**) blanking band. The units of this index are mm per km (inch per mile). When there is a segment of 76.2 m (**250 feet**) or less in length, the profilograph measurements for that segment shall be added to and included in the evaluation of the adjacent section to that segment.

Bumps and dips equal to or exceeding 10.2 mm in a 7.62 m (**0.4 inch in a 25 foot**) span shall be identified separately. When the profile trace shows a successive, uninterrupted bump, dip; or dip, bump combination (up to a maximum of 3 alternating trace deviations that relate to one bump or dip on the roadway), identify and evaluate these occurrences as one event.

C5 Surface Correction

All areas represented by deviations of 28 mm (**1.1 inch**) or more, as measured by the 7.62 m (**25 foot**) profilograph, will be corrected by the Contractor.

The Contractor may elect to correct pavement segments having no more than two events or two individual bumps or dips with a vertical deviation of 10.2 to 25 mm in a 7.62 m (**0.4 to 1.0 inch in a 25 foot**) span. Correction of segments with more than two events or two individual bumps or dips, as defined above, will be allowed only when approved by the Engineer. The Contractor will be assessed a penalty for dips or bumps of 10.2 to 25 mm (**0.4 to 1.0 inch**) that are not corrected. Bumps and dips not corrected will also be included in the evaluation for the segment smoothness. Corrected dips or bumps will be considered satisfactory when the profilogram shows the dips or bumps are less than 10.2 mm in a 7.62 m (**0.4 inch in a 25 foot**) span.

Bump, dip, and smoothness correction work shall be for the entire traffic lane width. Pavement cross slope shall be maintained through corrective areas.

All corrective work shall be made by diamond grinding or approved equivalent, overlaying the area, by replacing the area or by inlaying. The Contractor shall notify the Engineer prior to commencement of the corrective action. If the surface is corrected by grinding, all ground areas shall be treated with an emulsified asphalt fog seal conforming to Specification 2355. If the surface is corrected by overlay, inlay or replacement, the surface correction shall begin and end with a transverse saw cut.

2350.7

If the smoothness evaluation indicates that corrective work is necessary for more than 50% of a segment, surface correction will be limited to mill and inlay (40 mm (1 ½") min).

All corrective work shall be subject to the approval of the Engineer. After all required correction work is completed a final profile index shall be determined. Corrective work and re-evaluation will be at the Contractor's expense.

C6 Payment

The cost of certified smoothness testing and associated traffic control will be incidental to the cost of the Wear Course Mixture.

The Contractor may receive an incentive payment or be assessed a penalty based on the number of segments and the initial profile index. The total ride incentive shall not exceed 15% of the total mix price. Pay adjustments for incentives will only be based on the initial Profile Index before any corrective work has been performed. Pavement that contains corrective action for profile or bumps is not eligible for incentive pay. These payments or assessments will be based on the following schedules.

The Contractor will not receive an incentive payment for ride if more than 25% of all density lots for the project (mainline paving) fail to meet minimum density requirements.

For each traffic lane, a \$900 penalty will be assessed for each bump or dip of 10.2 to 25 mm (**0.4 to 1.0 inch**) that is not corrected. The Engineer may, at his discretion, assess a penalty in lieu of requiring the Contractor to take corrective action when the profile index for a segment indicates corrective action is necessary.

Penalties, based on the table the profile index is evaluated under, are as follows:

Table 2350-13A: \$560 per 0.1 km (**\$900 per 0.1 mile**)

Table 2350-13B: \$420 per 0.1 km (**\$675 per 0.1 mile**)

Table 2350-13C: \$280 per 0.1 km (**\$450 per 0.1 mile**)

Table 2350-13 A
Initial Profile Index ⁽¹⁾

| mm/ km (Inches per mile) per 0.1 km segment (per 0.1 mile segment) | Dollars per Segment (Metric) | Dollars per Segment (English) |
|---|---|--|
| 0- 13.4 (0.0 - 0.8) | 190 | 300 |
| 13.5 - 25.3 (0.9 - 1.6) | 130 | 200 |
| 25.4 - 38.7 (1.7 - 2.4) | 70 | 100 |
| 38.8 - 78.9 (2.5 - 5.0) | 0 | 0 |
| 79.0 - 92.3 (5.1 - 5.8) | (70) | (100) |
| 92.4 - 105.7 (5.9 - 6.7) | (130) | (200) |
| 105.8 - 118.3 (6.8 - 7.5) | (190) | (300) |
| Over 118.3 Over 7.5 | Corrective Action | Corrective Action |

(1) If all segments in a project qualify for 100 percent payment with no grinding, the qualifying incentive payment will be increased by \$25 per metric segment and \$40 per English segment.

Table 2350-13 B
Initial Profile Index ⁽¹⁾

| mm/ km (Inches per mile) per 0.1 km segment (per 0.1 mile segment) | Dollars per Segment (Metric) | Dollars per Segment (English) |
|---|---|--|
| 0 - 15.8 (0.0 - 1.0) | 145 | 225 |
| 15.9 - 31.6 (1.1 - 2.0) | 100 | 150 |
| 31.7 - 47.3 (2.1 - 3.0) | 55 | 75 |
| 47.4 - 110.5 (3.1 - 7.0) | 0 | 0 |
| 110.6 - 126.3 (7.1 - 8.0) | (55) | (75) |
| 126.4 - 142.0 (8.1 - 9.0) | (100) | (150) |
| 142.1 - 157.8 (9.1- 10.0) | (145) | (225) |
| Over 157.8 Over 10.0 | Corrective Action | Corrective Action |

(1) If all segments in a project qualify for 100 percent payment with no grinding, the qualifying incentive payment will be increased by \$25 per metric segment and \$40 per English segment.

2350.7

Table 2350-13 C
Initial Profile Index ⁽¹⁾

| mm/ km (Inches per mile) per 0.1 km segment (per 0.1 mile segment) | Dollars per Segment (Metric) | Dollars per Segment (English) |
|---|---|--|
| 0 - 31.6 (0.0 - 2.0) | 95 | 150 |
| 31.7-47.4 (2.1-3.0) | 65 | 100 |
| 47.5-79.0 (3.1-5.0) | 35 | 50 |
| 79.1-158.0 (5.1-10.0) | 0 | 0 |
| 158.1-189.6 (10.1-12.0) | (35) | (50) |
| 189.7-221.2 (12.1-14.0) | (65) | (100) |
| 221.3-252.8 (14.1-16.0) | (95) | (150) |
| Over 252.8 (Over 16.0) | Corrective Action | Corrective Action |

(1) If all segments in a project qualify for 100 percent payment with no grinding, the qualifying incentive payment will be increased by \$25 per metric segment and \$40 per English segment.

2350.8 METHOD OF MEASUREMENT

A Asphalt Mixture

Asphalt mixture of each type will be measured separately by mass, based on the total quantity of material hauled from the mixing plant, with no deductions being made for the asphalt materials.

B Blank

C Asphalt Mixtures Measured by the Square Meter (Square Yard) per Specified Thickness (mm (inch)) and for Mixtures Measured by the (Square Yard inch)

Asphalt mixture of each type and for each specific course will be measured separately by area and the thickness shall be based on the planned dimension. The constructed thickness shall meet the tolerances set forth in section 2350.7A.

2350.9 BASIS OF PAYMENT

Payment for the accepted quantities of asphalt mixture used in each course at the Contract prices per unit of material will be compensation in full for all costs of constructing the asphalt surfacing as specified, including

2350.9

the costs of furnishing and incorporating any asphalt cement, mineral filler, hydrated lime, or anti-stripping additives that may be permitted or required.

If the Marshall density at the recommended or established asphalt content is in excess of 2565 kg/m³ (**160 pound per cubic foot**), payment for mixture will be calculated at the following percent of the contracted unit price.

$$\% \text{ Payment} = \{100 - [\{100 \times (\text{Marshall Density} - 2565)\} / 2565]\}$$

$$\% \text{ Payment} = \{100 - [\{100 \times (\text{Marshall Density} - 160)\} / 160]\}_{\text{ENGLISH}}$$

In the absence of Contract items covering shoulder surfacing and other special construction, the accepted quantities of material used for these purposes will be included for payment with the wearing course materials.

Payment for the item of asphalt mixture production at the Contract unit price of mixture produced will be compensation in full for all costs of producing the mixture and loading it on board the Department's trucks at the mixing plant. The provisions of 1903 are modified to the extent that the Department will not make a price adjustment in the event of increased or decreased quantities of asphalt mixture items.

Payment for plant mixed asphalt surface will be made on the basis of the following schedule:

| Item No. | Item | Unit |
|-----------------|---|-------------------------------------|
| 2350.501 | Type (1) (2) Wearing Course Mixture ((4))..... | metric ton (ton) |
| 2350.502 | Type (1) (2) Non Wearing Course Mixture ((4))..... | metric ton (ton) |
| 2350.503 | Type (1) (2) (3) Course Mixture ((4)), (5) mm (inch) thick | square meter (square yard) |
| 2350.504 | Type (1) (2) (3) Course Mixture ((4))..... | (square yard inch) |
| 2350.505 | Type (1) (2) Bituminous Mixture for Specified Purpose | metric ton (ton) |
| 2350.506 | Type (1) (2) Bituminous Mixture Production | metric ton (ton) |

- (1) Traffic Level Designation (LV, MV, or HV as appropriate).
- (2) Aggregate size designation, as per Table 2350-1.
- (3) "Wearing" or "Non Wearing" as appropriate.
- (4) AC binder grade designation.
- (5) Specified lift thickness.

2355

2355

Bituminous Fog Seal

2355.1 DESCRIPTION

This work shall consist of treating an existing bituminous pavement to seal the surface.

2355.2 MATERIALS

A Bituminous Material.....3151

The bituminous material for fog seal shall be one of the following kinds and grades conforming to 3151.

- RC liquid Asphalt..... RC-70
- Emulsified Asphalt
 - AnionicSS-1, SS-1h
 - Cationic..... CSS-1, CSS-1h

2355.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Fog seal operations shall be conducted in a manner that will offer the least inconvenience to traffic, with movement in at least one direction permitted at all times without pickup or tracking of the bituminous material.

The fog seal shall not be applied until the road surface and weather conditions are acceptable to the Engineer.

For air temperatures greater than 4°C (40° F), asphalt emulsion shall be used unless it is no longer available for the season. When conditions require that liquid asphalt (RC-70) be used, the Engineer may require a light application of sand to prevent material pickup or tacking.

B Equipment

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C Road Surface Preparations

At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided in the Contract.

All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as approved by the Engineer.

D Application of Bituminous Material

The bituminous material shall be applied at a uniform rate of

- (1) 0.45 to 0.70 L per square meter (0.10 to 0.15 gallon per square yard) for diluted asphalt emulsion, or,
- (2) 0.45 L per square meter (0.10 gallon per square yard) for RC-70 cutback asphalt.

2356.2

The time and rate of application shall be as directed by the Engineer.

The temperature of the bituminous material at the time of application shall be as directed by the Engineer, within the limits specified below:

Liquid Asphalt RC-70..... 50 to 80°C (120-175°F)

Emulsified Asphalt

SS-1, SS-1h, CSS-1, CSS-1h.....20 to 70°C (120-175°F)

The asphalt emulsion shall be diluted with water, 50 percent by volume, to improve the material application and distribution characteristics. However, the added water will be excluded from the pay quantities.

Sand shall be spread on the newly fogged surface at pedestrian crossings unless otherwise directed by the Engineer.

2355.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material used for fog seal will be measured by volume at 15°C (60° F).

2355.5 BASIS OF PAYMENT

Payment for the accepted quantity of bituminous material used for fog seal at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified.

Furnishing and applying sand on the newly fogged surfaces shall be at no expense to the Department.

Payment for fog seal will be made on the basis of the following schedule:

| Item No. Item | Unit |
|---|----------------|
| 2355.502 Bituminous Material for Fog Seal | liter (gallon) |

2356

Bituminous Seal Coat

2356.1 DESCRIPTION

This work shall consist of an application of bituminous material followed by an application of cover aggregate on designated areas of an existing bituminous pavement.

2356.2 MATERIALS

A Bituminous Material.....3151

The bituminous material for seal coat shall be one of the following kinds and grades conforming to 3151. When the Contract quantity exceeds 7500 L (2000 gallons) , and unless other options are permitted by the Plans

2356.2

or Special Provisions, the kind to be used shall be emulsified asphalt, cationic grades. In all cases the grade to be used shall be as designated by the Engineer.

RC Liquid Asphalt RC-250, 800, 3,000

Emulsified Asphalt,

 Anionic RS-1, RS-2

 Cationic CRS-1, CRS-2

Asphalt Cement (penetration as specified)

B Seal Coat Aggregate 3127

The class of aggregate to be used will be shown in the Plans or indicated in the Special Provisions.

C Anti-Stripping Additive..... 3161

All bituminous material, except emulsions, shall be treated with an approved anti-stripping additive used in such quantity that the treated bituminous material will meet the pertinent requirements of 3161. The additive shall be added to the bituminous material at the refinery in a manner approved by the Engineer.

2356.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Seal coating operations (including traffic restrictions on the freshly constructed seal coat) shall be conducted:

- (1) Not before May 15 nor after August 31;
- (2) Only during daylight hours;
- (3) When the pavement and air temperature are 20°C (70° F) or higher;
- (4) When the relative humidity is less than 75 percent; and
- (5) When the road surface is dry and clean.

The seal coating operations shall not be started, and shall be suspended, when any one of the above conditions cannot be met.

B Equipment

B1 Distributor

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

B2 Aggregate Spreader

The cover aggregate shall be applied with an approved mechanical type aggregate spreader that is capable of distributing the aggregate uniformly to the required width and at the designated rate, with the application sharply defined at the edges.

The aggregate spreader shall be a self-propelled type mounted on pneumatic-tired wheels that are so located as to operate on the freshly applied aggregate.

B3 Pneumatic-Tired Roller

2356.3

The pneumatic-tired roller shall have a compacting width of 1.5 m (**5 feet**) or more and shall be so constructed that the gross mass of not less than 3500 kg per meter (**200 pounds per inch**) of rolling width can be varied as directed by the Engineer. The tire arrangement shall be such that full compaction will be obtained over the full width with each pass of the roller.

The roller may be self propelled or provided with suitable tractive equipment, unless the Contract specifies a certain type. If more than one roller propelled by a single tractive unit, the combination will be counted as a single roller unit.

B4 Paver Brooms

A rotary power broom shall be provided that is capable of cleaning the road surface prior to spraying bituminous material and to remove loose particles after treatment as required.

C Road Surface Preparations

At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided for in the Contract.

All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as the Engineer approves.

When specified in the Contract or ordered by the Engineer, a tack coat shall be applied to the prepared road surface in accordance with 2357.

D Application of Bituminous Seal Material

Application of bituminous material shall be governed by the rate at which the cover aggregate is applied and by the provisions made for maintenance of traffic. No traffic shall be permitted on uncovered bituminous material.

Bituminous material shall not be applied until the loaded aggregate spreader is on hand ready to begin application of aggregate immediately, with sufficient truck loads of aggregate at the site to cover the length of the anticipated applications of bituminous material.

The bituminous material for seal coat shall be applied to the road surface at a rate designated by the Engineer, within the limits specified below for the class of aggregate to be used.

TABLE 2356-1
SEAL COAT APPLICATION RATE
 Liters per Square Meter
 (Gallons per Square Yard)

| Aggregate | Emulsified or Liquid Asphalts | AsphaltCement |
|------------------|--------------------------------------|-------------------------|
| FA-1 | 0.68-0.91 (0.15 - 0.20) | - |
| FA-2 | 0.68-1.1 (0.15 - 0.25) | - |
| FA-3 | 0.91-1.6 (0.20 - 0.35) | 0.59-0.82 (0.13 - 0.18) |
| FA-4 | 1.4-2.0 (0.30 - 0.45) | 0.68-0.91 (0.15 - 0.20) |
| FA-5 | 1.8-2.3 (0.40 - 0.50) | 2.0-2.5 (0.45 - 0.55) |

To prevent overlapping at the end junction at transverse joints, means shall be provided to ensure positive cutoff for the bituminous material and cover aggregate. A section of building paper or other suitable material shall be placed across the lane to be coated and be positioned so that the forward edge is at the desired joint location. The distributor, traveling at the correct speed, shall start spraying on the building paper so that when the exposed surface is reached, the spray will be full and uniform. The same procedure shall apply to cover aggregate placement. The masking material used shall be removed and be disposed of in a manner approved by the Engineer.

Application of the bituminous material shall produce a uniform film without ridges and skips. Adjustments to the spray bar and nozzles shall be made prior to application of the bituminous material on the areas to be sealed.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified below:

| | |
|-----------------------------|--|
| Asphalt Cement | 175°C (350 ⁰ F) Max. |
| RC Liquid Asphalt | |
| RC-250..... | 74 to 105°C (165 to 220 ⁰ F) |
| RC-800..... | 93 to 107°C (200 to 225 ⁰ F) |
| RC-3000..... | 110 to 145°C (230 to 290 ⁰ F) |
| Cationic Emulsified Asphalt | |
| CRS-1,2... | 52 to 85°C (125 to 185 ⁰ F) |
| Anionic Emulsified Asphalt | |
| RS-1 | 21 to 60°C (70 to 140 ⁰ F) |
| RS-2 | 52 to 85°C (125 to 185 ⁰ F) |

E Application of Cover Aggregate

The cover aggregate shall be spread immediately following the application of bituminous material. Under no circumstances shall operations proceed in such manner that the bituminous material remains uncovered for more than 1 minute so as to set-up or dry-out to an extent that will impair retention of the cover aggregate.

The aggregate, at the time of spreading, shall not contain more than 2 percent (by mass) of free surface moisture, except that when FA-1 aggregate or an asphalt emulsion is used, the aggregate shall contain not more than 4 percent of free surface moisture.

The aggregate shall be spread uniformly over the full width of the bituminous application, at a rate designated by the Engineer, within the range of 20 to 25 kg per square meter (**40 to 50 pounds per square yard**) when FA-5 aggregate is used, or at the rate of 14 kg (**100 pounds**) of aggregate for each liter (**gallon**) of bituminous material used, per square meter (**square yard**).

To determine the volumetric rate of application, the mass per volume (truck measure) shall be determined by weighing a measured truck load on a scale furnished or made available by the Contractor.

Immediately after spreading the cover aggregate, any areas having non-uniform coverage shall be corrected to the satisfaction of the Engineer by removing excess material and spreading additional material over deficient areas. Variations in coverage exceeding 10 percent of the designated rate of application shall be corrected as ordered.

F Rolling Operations

Initial rolling shall follow immediately behind the spreading of cover aggregate, with the initial coverage completed within 5 minutes after spreading the aggregate. The surface rolling shall be continued until five complete coverages over the full width have been obtained. All rolling operations on an area shall be completed within 30 minutes after spreading the cover aggregate on that area.

All rolling shall be performed with approved self-propelled, smooth-tread pneumatic-tired rollers. A minimum of two rollers shall be used for rolling operations. The rollers shall not be operated at speeds exceeding 8 km/h (**5 miles per hour**). Rolling shall begin at the outer edge of the aggregate cover and proceed in a longitudinal direction, working toward the center of the road.

The completed surface shall present a uniform appearance. The surface shall be lightly broomed or otherwise maintained as necessary during the rolling operations to achieve uniform appearance.

G Protection of the Surface

No traffic shall be permitted on the sealed road surface until after all rolling has been completed and the bituminous material has set to a degree satisfactory to the Engineer and will not pick up on vehicle tires.

In addition to other barricades and warning signs required by the Contract, the Department will furnish and deliver to the Project such other barricades and warning signs as the Engineer deems necessary for use in conjunction with the seal coat construction. The Contractor shall

2356.3

erect and maintain those barricades and signs at locations directed by the Engineer.

The Contractor shall furnish traffic cones at least 450 mm (**18 inches**) in height and place them at intervals of not more than 60 m (**200 feet**) on the inner longitudinal edge of the freshly applied seal coat. These cones shall be maintained in place until the road is opened to unrestricted use by traffic.

When the road under construction is open to traffic during daylight hours, the Contractor shall furnish a minimum of two flagpersons and a pilot vehicle to direct and guide traffic through the construction zone. One flagger shall be stationed in advance of the seal coat operations and another at the rear barricade at the beginning of the uncovered bituminous material. It shall be the duty of the flagger to stop all traffic and to acquaint the traveling public with the nature of the work underway, the limitations on the road surface available for traffic use, and the reason for reduced driving speed.

The contractor shall provide a Traffic Control Plan consistent with the "Minnesota Manual on Uniform Traffic Control Devices (Mn MUTCD) and approved by the Engineer."

On the morning following each day of seal coat operations, the Contractor shall sweep the surplus aggregate from the previous day's seal coat construction. This operation shall be conducted while the road surface is still cool, and care shall be exercised that the aggregate that has set is not disturbed. Where sealing is done in municipalities, the Contractor shall dispose of the surplus aggregate in a manner satisfactory to the Engineer.

2356.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material applied on the road will be measured by volume at 15°C (60° F).

B Seal Coat Aggregate

Seal coat aggregate will be measured as indicated in the Proposal, by mass or LV of material deposited on the road.

2356.5 BASIS OF PAYMENT

Payment for the accepted quantities of bituminous material (including any required additives) and seal coat aggregate at the appropriate Contract prices will be compensation in full for all costs of constructing the seal coat as specified.

2356.3

Payment for the bituminous seal coat will be made on the basis of the following schedule:

| Item No. | Item | Unit |
|-----------------|---|-----------------------------|
| 2356.505 | Bituminous Material for Seal Coat | liter (gallon) |
| 2356.507 | Seal Coat Aggregate | metric ton (ton) |
| 2356.509 | Seal Coat Aggregate (LV) | cubic meter (yard) |

2357

Bituminous Tack Coat

2357.1 DESCRIPTION

This work shall consist of treating an existing bituminous or concrete surface with bituminous material preparatory to placing a bituminous course or seal coat thereon.

2357.2 MATERIALS

A Bituminous Material.....3151

The bituminous material for tack coat shall be one of the following kinds and grades conforming to 3151. When the Contract quantity exceeds 7500 L (**2000 gallons**), and except during periods of freezing temperatures, the tack coat material to be used will be limited to one of the kinds of emulsified asphalt. Otherwise, the kind to be used shall be optional with the Contractor. The grade to be used shall be as designated by the Engineer.

MC liquid Asphalt..... MC-250,800

2357.3

RC Liquid Asphalt C-70, 250, 800

Emulsified Asphalt,

Anionic..... SS-1, SS-1H, MS-2, RS-1, RS-2

Cationic..... CSS-1, CSS-1H, CRS-1, CRS-2

2357.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Tack coat operations shall be conducted in a manner that offers the least inconvenience to traffic, with movement in at least one direction permitted at all times without pickup or tracking of the bituminous material. The tack coat shall not be applied when the road surface or weather conditions are unsuitable. The daily application of tack coat shall be limited to approximately the area on which construction of the subsequent bituminous course can reasonably be expected to be completed that day.

B Equipment

2356.3

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C Road Surface Preparations

At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed as provided for in the Contract.

All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as the Engineer approves.

Preparatory to placing an abutting bituminous course, the contact surfaces of all fixed structures and the edge of the in-place mixture in all courses at transverse joints and in the wearing course at longitudinal joints shall be given a uniform coating of liquid asphalt or emulsified asphalt, applied by methods that will ensure uniform coating.

D Application of Bituminous Material

The bituminous material shall be applied at a uniform rate not to exceed:

- (1) 0.23 L per square meter (**0.05 gallon per square yard**) for cutback asphalt and undiluted asphalt emulsion (as supplied from the refinery).
- (2) 0.91 L per square meter (**0.02 gallon per square yard**) for diluted asphalt emulsion (with water added in the field).

The time and rate of application shall be as directed by the Engineer.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified following:

| | | |
|--------------------|--------------------------|--------------------------------------|
| Liquid Asphalt | RC-70 | 49 to 82°C (120 to 180° F) |
| | RC-250, MC-250 | 74 to 104°C (165 to 220° F) |
| | RC-800, MC-800 | 93 to 124°C (200 to 255° F) |
| Emulsified Asphalt | SS-1, SS-1H, MS-2, | |
| | CSS-1, CSS-1H | 21 to 71°C (70 to 160° F) |
| | RS-1 | 21 to 60°C (70 to 140° F) |
| | 5S-2, CRS-1, CRS-2 | 52 to 85°C (120 to 185° F) |

For asphalt Grades SS-1, SS-1H, CSS-1, and CSS-1H, water may be added up to 50 percent by volume to improve the material application and distribution characteristics. However, the added water will be excluded from the pay quantities.

Unless otherwise directed, sand shall be spread on the newly tacked surface at pedestrian crossings.

2357.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material used for tack coat will be measured by volume at 15⁰C (60⁰ F)

2357.5 BASIS OF PAYMENT

Payment for the accepted quantity of bituminous material used for tack coat at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified.

Furnishing and applying sand on newly tacked surfaces at pedestrian crossings shall be at no expense to the Department with no direct compensation being made therefor.

Should the Contract fail to include a Contract Item covering payment for the bituminous material used for tack coat, all costs of furnishing and applying bituminous tack coat material will be included in the compensation provided for the bituminous mixture, with no measurement made of the bituminous material used and with no direct compensation being made therefore.

Payment for the tack coat will be made on the basis of the following schedule:

| Item No. Item | Unit |
|---|-------------------------|
| 2357.502 Bituminous Material for Tack Coat..... | liter (gallon) |

2358

Bituminous Prime Coat

2358.1 DESCRIPTION

This work shall consist of treating a prepared base with bituminous material preparatory to placing a bituminous course thereon.

2358.2 MATERIALS

A Bituminous Material.....3151

The bituminous material for the prime coat shall conform to the requirements for one of the following kinds and grades, subject to any limitations imposed by the Contract. If any options are permitted, the kind to be used shall be optional with the Contractor but the grade shall be as designated by the Engineer.

MC Liquid Asphalt..... MC-30, 70

2358.3 CONSTRUCTION REQUIREMENTS

A Restrictions

Bituminous prime coat shall not be applied at any time when the moisture content of the upper 80 mm (**3 inches**) of the base is more than 65 percent of optimum moisture, or when the weather or road surface conditions are otherwise unsuitable for proper construction.

2358.3

When traffic is being maintained over the section of road under construction, not more than 50 percent of the traveled way shall be closed to traffic at any one time, and traffic movement in at least one direction shall be permitted at all times without pick up or tracking of the bituminous material.

B Equipment

The bituminous material shall be applied with a distributor meeting the requirements of 2321.3C1.

C Road Surface Preparations

At the time of applying the bituminous material, the subgrade shall be in acceptable condition, with all preparation and maintenance operations completed as required by other provisions of the Contract.

D Application of Bituminous Material

The bituminous material shall be applied in a uniform, continuous spread at the rate of 0.45 to 1.35 L square meter (**0.1-0.3 gallons**) and in one or two applications, as directed by the Engineer.

Care shall be taken that the application of bituminous material at the junction of spreads is not in excess of the specified quantity. Excess bituminous material shall be squeegeed from the surface. Skipped areas and deficiencies shall be corrected.

The temperature of the bituminous material at the time of application shall be as approved by the Engineer, within the limits specified below.

| | | |
|-------------------|------------|-------------------------------------|
| MC Liquid Asphalt | MC-30..... | 29 to 63°C (85 to 145° F) |
| | MC-70..... | 49 to 82°C (120 to 180° F) |

2358.4 METHOD OF MEASUREMENT

A Bituminous Material

Bituminous material for prime coat will be measured by volume at 15°C (**60° F**).

2358.5 BASIS OF PAYMENT

Payment for the accepted quantity of bituminous material used for prime coat at the Contract price per unit of measure will be compensation in full for all costs of furnishing and applying the material as specified, exclusive of those costs which are to be compensated for separately under other Contract items.

Payment for the prime coat will be made on the basis of the following schedule.

| Item No. Item | Unit |
|---|-------------------------|
| 2358.501 Bituminous Material for Prime Coat | liter (gallon) |

2360
PLANT MIXED BITUMINOUS PAVEMENT
(SUPERPAVE)

2360.1 DESCRIPTION

This work consists of the construction of one or more pavement courses of Superpave hot plant mixed asphalt-aggregate mixture on the approved prepared foundation, base course or existing surface in accordance with the specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Engineer.

A Design Criteria

The type(s) of mixture shall be delineated in the Special Provisions and are identified as Type SP 9.5, Type SP12.5, or Type SP 19.0. The mixtures are further identified as Type SP xx.x wear and Type SP xx.x non wear.

A1 20 Year Design ESAL's (Specified in the Special provisions)

Mainline Design ESAL's ___ - ___ million

Shoulder Design ESAL's ___ - ___ million

The requirements for type SP HMA mixtures are based on the 20 year design traffic level of the project, expressed in 80 kN (**18,000 pounds**) Equivalent Single Axle Loads (ESAL's). The seven traffic levels are shown in Table 2360-1.

Table 2360-1
Superpave Traffic Levels

| Traffic Level | 20 Year Design ESAL's (1×10^6 ESAL's) |
|---------------|---|
| 1 | ≤ 0.3 |
| 2 | $0.3 \leq 1$ |
| 3 | $1 \text{ to } \leq 3$ |
| 4 | $3 \text{ to } \leq 10$ |
| 5 | $10 \text{ to } \leq 30$ |
| 6 | $30 \text{ to } \leq 100$ |
| 7 | > 100 |

A2 Mixture and PG Asphalt binder

(Specified in the Special Provisions)

Mainline non wear Type SP xx.x PG ___ - ___

Mainline wear Type SP xx.x PG ___ - ___

Shoulder Type SP xx.x PG ___ - ___

2360.1

B Minimum Lift thickness

- SP 9.5 wear Minimum Lift thickness = 40 mm (**1½ inch**)
- SP 12.5 wear or non wear
..... Minimum Lift thickness = 50 mm (**2 inches**)
- SP 19.0 non wear only
..... Minimum Lift thickness = 75 mm (**3 inches**)

2360.2 MATERIALS

The Superpave HMA shall be composed of a combination of aggregate (coarse, fine or mixtures thereof), mineral filler, if required, and performance graded asphalt binder material.

A Asphalt Binder Material AASHTO MP-1

Asphalt binder material shall meet the requirements of PG asphalt binder testing tolerances, sampling rates, testing procedures, and acceptance criteria based on the most current Mn/DOT technical memorandum titled, “ Inspection, Sampling, and Acceptance of Bituminous Materials.” The PG asphalt binder cannot be modified with air blowing procedures unless it is approved by the Bituminous Office. The Contractor shall not use petroleum distillates such as fuel oil, diesel fuel or other fuels in the asphalt binder tanks. A statement shall be provided by the supplier for recommended laboratory mixing and compaction temperatures and field maximum mixing and compaction temperatures.

B Additives

An additive is any material added to a asphalt mixture or material, such as mineral filler, hydrated lime, asphalt additives, anti-strip, and similar products that do not have a specific pay item. When a Contract requires additives, compensation is included with the pay items for the appropriate mixture. If the Engineer directs the Contractor to incorporate additives, the compensation will be as Extra Work. The Department will not compensate the Contractor for additives incorporated at the Contractor's option.

Additives shall not be incorporated into the mixture without approval of the Department Bituminous Engineer. Anti-foaming agent shall be added to asphalt cement at the manufacturer's recommended dosage rate. Mineral filler and hydrated lime may be added in a quantity not to exceed 5 percent and 2 percent, respectively, of the total mass of the aggregate. The combination of mineral filler and hydrated lime shall not exceed 5 percent of the total mass of aggregate. The Engineer will approve or disapprove methods for addition of additives.

- B1 Mineral Filler..... 3145
- B2 Hydrated Lime..... ASTM C977

Hydrated lime used in asphalt mixtures shall meet the requirements of ASTM C977 and have a maximum of eight percent unhydrated

2360.1

oxides (as received basis). The method of introducing and mixing the hydrated lime and aggregate shall be subject to approval by the Engineer prior to beginning mixture production.

B3 Liquid Anti-Stripping Additive

When a liquid anti-strip additive is added to the asphalt binder, blending shall be completed before the asphalt binder is mixed with the aggregate. Liquid anti-strip additives that modify the asphalt binder, such that it fails to meet the Performance Grade (PG) requirements, shall not be used. No paving will be allowed until the asphalt binder / additive blend has been tested and the results meet the criteria in 2360.2A. The Company adding the additive will be responsible for testing the binder / additive blend to ensure compliance with the standard specification for performance graded asphalt binder AASHTO MP-1 .

B4 Coating and Anti-Stripping Additive..... 3161

C Gradation Requirement

The coarse and fine aggregate shall be combined in such proportions to produce an asphalt mixture meeting all of the requirements defined in this specification and shall conform to the gradation as defined in Table 2360-2. Gradation testing shall be conducted in accordance with AASHTO T-11 (-minus 0.075 mm (#200) wash) and T-27.

**Table 2360-2
Aggregate Gradation Broad Bands**

| Sieve Size | Superpave Mixture (Percent Passing) | | | | | |
|--------------|--|------|--|------|--|------|
| | SP 9.5 9.5 mm (3/8 inch) Nominal size | | SP 12.5 12.5 mm (½ inch) Nominal size | | SP 19.0 19.0 mm (3/4 inch) Nominal size | |
| | Min. | Max. | Min. | Max. | Min. | Max. |
| 25.0 (1) | - | - | - | - | 100 | - |
| 19.0 (3/4) | - | - | 100 | - | 90 | 10 |
| 12.5 (½) | 100 | - | 90 | 100 | - | 90 |
| 9.5 (3/8) | 90 | 100 | - | 90 | - | - |
| 4.75 (#4) | - | 90 | - | - | - | - |
| 2.36 (#8) | 32 | 67 | 28 | 58 | 23 | 49 |
| 0.075 (#200) | 2 | 8 | 2 | 8 | 2 | 7 |

C1 Gradation Restricted Zone:

The recommended design gradation, identified in Table 2360-2 should avoid the restricted zones specified in Table 2360-3.

2360.2

**Table 2360-3
Recommended Aggregate Gradation Restricted Zone**

| Sieve Size within Restricted Zone | Boundaries of Restricted Zone Superpave Mixture (Percent Passing) | | | | | |
|-----------------------------------|---|------|--|------|--|------|
| | SP 9.5 9.5 mm (3/8 inch) Nominal size | | SP 12.5 12.5 mm (1/2 inch) Nominal size | | SP 19.0 19.0 mm (3/4 inch) Nominal size | |
| | Min. | Max. | Min. | Max. | Min. | Max. |
| 2.36 mm (#8) | 47.2 | 47.2 | 39.1 | 39.1 | 34.6 | 34.6 |
| 1.18 mm (#16) | 31.6 | 37.6 | 25.6 | 31.6 | 22.3 | 28.3 |
| 0.60 mm (#30) | 23.5 | 27.5 | 19.1 | 23.1 | 16.7 | 20.7 |
| 0.30 mm (#50) | 18.7 | 18.7 | 15.5 | 15.5 | 13.7 | 13.7 |

D Consensus Aggregate Properties:

All consensus aggregate properties are based upon the design ESAL's for mainline or shoulder mixtures as specified in the special provisions. The aggregate blend shall meet the following consensus properties.

D1 Coarse Aggregate Angularity (CAA) ASTM D 5821

The coarse aggregate blend shall meet the coarse aggregate angularity requirement defined in Table 2360-4.

**Table 2360-4
Coarse Aggregate Angularity
(Minimum Percent Fractured Faces)**

| Traffic Level | Depth of Pavement from Surface | | | |
|---------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| | ≤ 100 mm (4 inch) | | >100 mm (4 inch) & Shoulders | |
| | One or More Fractured Faces (%) | Two or More Fractured Faces (%) | One or More Fractured Faces (%) | Two or More Fractured Faces (%) |
| 1 | 55 | - | - | - |
| 2, 3 | 75 | - | 50 | - |
| 4 | 85 | 80 | 60 | - |
| 5 | 95 | 90 | 80 | 75 |
| 6, 7 | 100 | 100 | 100 | 100 |

Note: If less than 25% of a layer is with in 100 mm (4 inch) of the surface, the layer may be considered to be below 100mm (4 inch) for mix design purposes.

2360.2

D2 Fine Aggregate Angularity (FAA) . ASTM C1252 Method A

The fine aggregate blend shall meet the fine aggregate angularity requirement for the composite aggregate blend as defined in Table 2360-5.

**Table 2360-5
Fine Aggregate Angularity**

| Traffic Level | Depth of Pavement from Surface | |
|---------------|--------------------------------------|--------------------------------------|
| | ≤ 100 mm (4 inch) | >100 mm (4 inch) & Shoulders |
| | Minimum Uncompacted Void Content (%) | Minimum Uncompacted Void Content (%) |
| 2, 3 | 40 | 40 |
| 4, 5 | 45 | 40 |
| 6, 7 | 45 | 45 |

D3 Flat and Elongated Particles ASTM D 4791

The maximum amount of flat and elongated particles by mass for the coarse aggregate + 9.5 mm (3/8 inch) blend shall not exceed 10% for all projects with traffic level 3 or above. Flat and Elongated particles are the percentage of coarse aggregate, as defined in ASTM D 4791, where the ratio of length to width or width to thickness is greater than three to one.

D4 Clay Content.....AASHTO T 176

The fine aggregate blend shall have a sand equivalent value meeting the requirements defined in Table 2360-6.

**Table 2360-6
Clay Content**

| Traffic Level | Sand Equivalent Minimum (%) |
|---------------|-----------------------------|
| 1,2,3 | 40 |
| 4,5 | 45 |
| 6,7 | 50 |

E Source Specific Aggregate Properties:

Individual aggregate components shall be tested and meet the following quality requirements:

E1 Los Angeles Abrasion (Toughness Test).....AASHTO T 96

The Los Angeles Rattler loss on the coarse aggregate fraction (material retained on the 4.75 mm (#4) sieve shall not exceed 40 percent for any individual source used within the mix. An aggregate proportion which passes the 4.75 mm (#4) sieve and exceeds 40 percent LAR loss

2360.2

on the coarse aggregate fraction is prohibited from use in the mixture. Tested on class A, B, C, D, and E aggregates as defined in 3139.

E2 Magnesium Sulfate (Soundness Test)..... AASHTO T 104

The magnesium sulfate soundness loss on the coarse aggregate fraction (material retained on the 4.75 mm (#4) sieve) shall not exceed the following for any individual source used within the mix:

- a. 14 % loss on the 19 mm (3/4 inch) to 12.5 mm (1/2 inch) and larger fractions.
- b. 18% loss on the 12.5 mm (1/2 inch) to 9.5 mm (3/8 inch) fraction.
- c. 23% loss on the 9.5 mm (3/8 inch) to 4.75 mm (#4) fraction.
- d. 18% for the composite loss (Applies only if all three size fractions are tested).

An aggregate proportion which passes the 4.75 mm (#4) sieve and exceeds the loss requirements listed above on the coarse aggregate fraction is prohibited from use in the mixture.

E3 Total Spall and Lumps (Deleterious Materials Test) Mn/DOT Lab Manual 1209

Spall is defined as shale, iron oxide, unsound cherts, pyrite, highly weathered and/or soft phyllite and argillite (can be scratched with a brass pencil), and other materials having similar characteristics. Spall is measured on the total sample.

Lumps are defined as loosely bonded aggregations and clayey masses. If the percent of lumps measured in the stockpile or cold feed exceed the values listed below, asphalt production shall cease and compliance shall be determined by dry batching. This procedure may be repeated at any time at the discretion of the Engineer. The aggregate shall not exceed the maximum shown in Table 2360-E3.

**Table 2360-E3
Spall Material and Lumps**

| Traffic Level | Total Spall in fraction retained on the 4.75 mm (#4) sieve | Maximum Shale Content of fraction passing 4.75 mm (#4) sieve | Maximum percent Lumps in fraction retained on 4.75 mm (# 4) sieve |
|---------------|--|--|---|
| 1, 2 | 5.0 | 5.0 | 0.5 |
| 3 | 2.5 | 5.0 | 0.5 |
| 4 - 7 | 1.0 | 5.0 | 0.5 |

E4 Insoluble Residue (Soundness Test) Mn/DOT Lab Manual 1221

2360.2

The minus 75 μm (**#200**) sieve size portion of the insoluble residue shall not exceed 10%. Tested on class B only as defined in 3139.

E5 Aggregate Specific Gravity
.....AASHTO T84 and T85, Mn/DOT modified.

Testing shall be conducted on all aggregate used in the mixture.

E6 Fine Aggregate and Mineral Filler:

All material passing the 4.75 mm (**#4**) sieve and retained on the 0.075 mm (**#200**) sieve shall be considered as fine aggregate. The material passing the 0.075 mm (**#200**) sieve shall be considered as mineral filler.

E7 Recycled Asphaltic Pavement Materials (RAP)

The Contractor may use a maximum of 20% RAP in a Superpave mix subject to the following conditions.

1. The Contractor is responsible for the design of Superpave mixtures that incorporate RAP. The composite aggregate shall comply with the consensus properties included in 2360.2C and 2360.2D.
2. Source aggregate properties described in section 2360.E5 shall be determined by testing a representative chemically extracted RAP sample.
3. The percent asphalt binder content in the RAP must be determined according to Mn/DOT lab manual method 1851 or 1852 on file in the Bituminous Office.
4. RAP containing any objectionable material, i.e. road tar, metal, glass, wood, plastic, brick, fabric or any other material having similar characteristics will not be permitted for use in the HMA mixture.

F Mixture Requirements:

The aggregate fractions shall be sized, graded and combined in such proportions that the resulting mixture will meet the grading and physical properties (2360.2C, 2360.2D, and 2360.2E) of the approved mix design. The gradation shown on the mix design shall be within the range specified

in Table 2360-2. Gradation is a design and acceptance/process control requirement.

F1 Aggregate Restrictions

Class B carbonate aggregate shall be limited in Superpave mixtures as follows:

2360.2

**Table 2360-F1
Aggregate Restriction**

| Traffic Level | Maximum % minus 4.75 mm (#4) | | Maximum % plus 4.75 mm (#4) | |
|---------------|------------------------------|-----------------|-----------------------------|-----------------|
| | Final Lift | All other Lifts | Final Lift | All other Lifts |
| 1-3 | 90 | 90 | 100 | 100 |
| 4 | 80 | 80 | 50 | 100 |
| 5-7 | 50 | 80 | 0 | 100 |

F2 Gyrotory Compaction:

The design mixture shall be compacted in accordance with AASHTO TP-4. The number of gyrations shall be as defined in Table 2360-7.

**Table 2360-7
Superpave Design Gyrotory Compactive Effort**

| Traffic Level | N _{initial} | N _{design} | N _{maximum} |
|---------------|----------------------|---------------------|----------------------|
| 1 | 6 | 50 | 75 |
| 2,3 | 7 | 75 | 115 |
| 4 | 8 | 90 | 140 |
| 5 | 8 | 100 | 160 |
| 6,7 | 9 | 125 | 205 |

F3 Volumetric Criteria:

The design air void content of the mixture at design shall be 4.0% at the design number of gyrations (N_{design}) for mixtures placed in the upper 100 mm (**4 inch**) of the finished surface. The design air void content of the mixture at design shall be 3.0% at the design number of gyrations (N_{design}) for mixtures placed at depths more than 100 mm (**4 inch**) from the surface and on all (wear and non wear) shoulders that do not carry traffic. Volumetric criteria for N_{initial}, N_{design}, and N_{max} are design and acceptance/process control requirements.

**Table 2360-8
Mixture Densification Criteria**

| Gyration Level | Criteria for % G _{mm} (≤ 100 mm (4 inch) from Surface) | Criteria for % G _{mm} (> 100 mm (4 inch) from Surface) & Shoulders |
|----------------------|--|--|
| N _{initial} | < 89.0 ⁽¹⁾ | < 90.0 ⁽¹⁾ |
| N _{design} | = 96.0 | = 97.0 |
| N _{maximum} | < 98.0 | < 99.0 |

(1)

2360.2

(1) Traffic level 1 maximum increase to 91.5 and traffic level 2 maximum increase to 90.5.

F4 VMA Criteria:

The voids in the mineral aggregate (VMA) of the mixture during design and production shall meet the minimum criteria as shown in Table 2360-9 at the design number of gyrations. VMA shall be calculated according to procedures outlined in the Asphalt Institute’s Superpave SP-2 manual. VMA is a design and acceptance / process control requirement.

**Table 2360-9
VMA Criteria**

| Type Mix Nominal size | Fine Mixture % Pass 2.36 mm (#8) | VMA (%) Minimum | Coarse Mixture % Pass 2.36 mm (#8) | VMA (%) Minimum |
|--------------------------|--|--------------------|--|--------------------|
| SP 9.5 | > 47 | 15.0 | ≤ 47 | 14.5 |
| SP 12.5 | >39 | 14.0 | ≤ 39 | 13.5 |
| SP 19.0 | >35 | 13.0 | ≤ 35 | 12.5 |

F5 VFA Criteria:

The voids filled with asphalt (VFA) criteria of the mixture at design shall be as shown in Table 2360-10 at the design number of gyrations. VFA is a design requirement.

**Table 2360-10
VFA Criteria**

| Traffic Level | Design VFA % ≤ 100 mm (4 inch) from surface | Design VFA % >100 mm (4 inch) & Shoulders |
|---------------|---|---|
| 1 | 70.0 - 80.0 | 75 - 85 |
| 2, 3 | 65.0 - 78.0 | 70 - 83 |
| 4 - 7 | 65.0 - 75.0 ⁽¹⁾ | 70 - 80 ^{(2), (3)} |

- (1) 9.5 mm (3/8 inch) mixtures upper limit increase to 76.0%
- (2) 9.5 mm (3/8 inch) mixtures upper limit increase to 82.0%
- (3) 12.5 mm (1/2 inch) mixtures upper limit increase to 81.0%

F6 Fines to Effective Asphalt Ratio Requirement:

The effective asphalt binder content shall be calculated in accordance with the Asphalt Institute method in MS-2 (sixth edition, Chapter 4). The fines to effective asphalt content by mass shall be 0.6 to 1.2 except, in mixtures whose gradation passed beneath the restrict zone as shown

2360.2

in Table 2360-3, the fines to effective asphalt content by mass shall be 0.8 to 1.6.

F7 Moisture Damage Susceptibility:

The retained tensile strength ratio of the mixture (150 mm (**6 inch**) specimens) shall be 80.0 % or greater and shall be tested in accordance with ASTM D-4867, Mn/DOT modified. The Department will test a resubmitted mix once. Subsequent requests must be accompanied by mixture containing an anti-strip agent or an aggregate composition change.

2360.3 MIXTURE DESIGN

A Mixture Design General

The asphalt mix may be designed using one of the following Contractor trial mix design options. Review and approval of mixture designs will be performed in the District Materials Laboratory where the project is located. The addition of aggregates and materials not included in the original mixture submittal is prohibited.

It shall be the Contractor's responsibility to design the Superpave asphalt mixture in accordance with AASHTO TP-4 or the Asphalt Institute's Superpave Mix Design Manual SP-2 (2-hour short term aging period is used for volumetric), such that it meets the requirements of this specification. The Contractor shall follow 2360.3B, 2360.3C, or 2360.3D for mix design and verification.

Proportion changes which exceed 10% of any single stockpile aggregate, from the original mix design Submittal, will be considered a new mix design. New mix designs must meet all material requirements as described in 2360.2 and 2360.3.

B Laboratory Mixture Design (Option 1)

Test results and documentation as described in section 2360.3E shall be submitted with the materials described below for consideration by the Department Bituminous Engineer or District Materials Engineer to verify compliance with these specifications and to issue a Department approved HMA Paving Recommendation.

B1 Aggregate sample

At least 15 working days prior to the start of asphalt production, the Contractor shall submit to the Department Bituminous Engineer or the District Materials Engineer a 35 kg (**75 pound**) sample of representative aggregate retained on the 4.75 mm (# 4) sieve and a 15 kg (**35 pound**) sample of material passing the 4.75 mm (#4) sieve. These samples will be tested for each source, class, type, and size of virgin and non-asphaltic salvage aggregate source used in the mix design.

Aggregates that require the magnesium sulfate soundness test shall be submitted to the Department Bituminous Engineer or District Materials Engineer at least 30 calendar days prior to the start of asphalt production.

2360.3

B2 Mixture sample

At least 7 working days prior to the start of asphalt production, the Contractor shall submit in writing a proposed Job Mix Formula (JMF) for each combination of aggregates to the Department Bituminous Engineer or District Materials Engineer for review and approval. This proposed JMF must be signed by a Level II Quality Management mix designer. For each JMF submitted, the Contractor shall include test data to demonstrate conformance to material properties as specified in Section 2360.2. The proposed JMF shall be submitted on forms approved by the Department. In addition, the Contractor shall submit a 50 kg (**110 pound**) uncompacted sample plus two Gyratory briquettes compacted at the optimum asphalt binder content and gyrations conforming to the JMF for laboratory examination and evaluation.

B3 Tensile Strength Ratio sample

Mixture or Gyratory specimens, that represent the mixture at optimum asphalt content, shall be submitted at least 7 days prior to actual production for verification of the moisture sensitivity retained tensile strength ratio (TSR). Material submitted for TSR verification may be tested for maximum specific gravity G_{mm} compliance in addition to TSR results.

Failure to meet the G_{mm} tolerance will result in rejection of the submitted mix design. A new mix design Submittal will be required and will be subject to provisions described in 2360.3E. One of the following options may be used to verify that the tensile strength ratio (TSR) meets the requirements as described in 2360.2F7.

Option 1) The Contractor will batch material at the design proportions including optimum asphalt. Immediately (before curing) split sample and allow samples to cool to room temperature. Submit 25 kg (**55 pound**) of mixture to the District Materials Laboratory lab for curing and test verification. Both groups will use a 2 hour cure time, \pm 15 minutes, at 135°C (**275°F**) and follow remaining procedures in ASTM D 4867-92, Mn/DOT modified.

Option 2) The Contractor batches, cures (as indicated in option #1), compacts, and submits a minimum of 6 Gyratory specimens at the required 6.5 to 7.5% air void content and 8200 grams of uncompacted mixture.

C Produced Mixture Design (Option 2)

Test results and documentation as described in section 2360.3E shall be submitted with materials described below for consideration by the Department Bituminous Engineer or District Materials Engineer to verify compliance with these specifications and issuance of a Department approved HMA Paving Recommendation.

C1 Aggregate Sample

2360.3

At least 15 working days prior to supplying mixture to a Department Project, the Contractor shall submit to the Department Bituminous Engineer or the District Materials Engineer a 35 kg (**75 pound**) sample of representative aggregate retained on the 4.75 mm (#4) sieve and a 15 kg (**35 pounds**) sample of material passing the 4.75 mm (#4) sieve. These samples will be tested for each source, class, type, and size of virgin and non-asphaltic salvaged aggregate source used in the mix design.

Aggregates that require the magnesium sulfate soundness test shall be submitted to the Department Bituminous Engineer or District Materials Engineer at least 30 calendar days prior to the start of asphalt production.

C2 Mixture Sample

At least 5 working days prior to supplying mixture to a Department project, the Contractor shall provide the Department Bituminous Engineer or District Materials Engineer with the data and samples of material from

at least four consecutive quality control test results, as shown in 2360.4E, representing the most recent Quality Management certified production of the mixture for review and approval. The Contractor shall supply sufficient material or Gyrotory specimens as described in option 1 for verification of Tensile Strength Ratio. If these test results show the mixture to be in compliance with the requirements of 2360.2F a paving recommendation may be issued based on previously produced material. Compliance shall include the moving average of 4 test results compared to the warning limits and each single test result as compared to twice the warning limits shown in Table 2360-11.

D Laboratory Mixture Design/Initial Production Test Strip Verification (Option 3)

D1 Laboratory Mix Design

The Contractor shall meet the requirements shown in 2360.3B, 2360.3B1, and 2360.3B3; this excludes the mixture submittal portion of 2360.3B2.

D2 Initial Production test Strip Verification

For initial use of a Type SP mix design at a particular plant, full-scale production and placement of the mix shall be limited to 500 metric tons (**550 tons**) for each mix type in order to demonstrate the capability of producing, placing, and compacting the mix as specified. During this period, the Contractor shall take a minimum of 2 separate sets of mixture samples which will be used for extraction gradation analysis and determination of volumetric properties. These samples shall be 50 kg (**110 pound**) total to be split with between the Contractor and Department. Production will cease until mixture properties are tested and evaluated by both the Contractor and the Department. Results must be within the allowable testing tolerances shown in Table 2360-13.

2360.3

Production may be resumed upon determination of acceptable extraction gradation analysis in accordance with 2360.2C, consensus properties in 2360.2D and mixture requirements in accordance with 2360.2F. Acceptable verification will be determined based upon the average of the two sample test results.

If the gradation, design air voids, VMA, and % asphalt binder are within the specified tolerance as shown in the proposed JMF and within specified control limits in Table 2360-11, and the retained tensile strength ratio was successfully tested and accepted as indicated in section 2360.3B3; the initial moisture damage susceptibility verification shall be accepted and production may be resumed. If any of these parameters fail to be verified within tolerances, the mixture submitted must be tested and evaluated for moisture damage sensitivity criteria acceptance, prior to full scale production.

All mixture placed on Mn/DOT projects shall meet the specified quality indicators and required field density. Failure to do so will result in reduced payment or removal and replacement with acceptable material.

This includes initial production 500 metric ton (**550 ton**) lots used for mixture verification.

Failure to meet the specified verification of mixture properties after three consecutive 500 metric ton (**550 ton**) lots will require the Contractor to use Option 1 (2360.3B) or Option 2 (2360.3C).

E Documentation

Each proposed JMF submitted under 2360.3B, 2360.3C, and 2360.3D shall include the following documentation and test results.

- (1) The name(s) of the individual(s) responsible for the Quality Control of the mixture during production.
- (2) The low State project number on which the mixture will be used.
- (3) The design traffic level and the initial, design, and maximum number of gyrations N_{initial} , N_{design} , and N_{maximum} .
- (4) The percentage in units of 1 percent (except the 0.075 mm (#200) sieve in units of 0.1 percent) of aggregate passing each of the specified sieves for each aggregate to be incorporated into the mixture. The gradation of aggregate from salvaged asphaltic material shall be derived from the material after the residual asphalt has been extracted.
- (5) The source and description of the materials to be used. The aggregate pit or quarry source number. The proportion of each material (in percent of total aggregate).
- (6) The composite gradation based on (4) and (5) above. Note: Include virgin composite gradation based on (4) and (5) above for mixtures containing RAP.

2360.3

- (7) The test results from the composite aggregate blend at the proposed JMF proportions indicating compliance with Coarse Aggregate Angularity Table 2360-4 and Fine Aggregate Angularity as shown in Table 2360-5.
- (8) The bulk (dry) and apparent specific gravities and water absorption (by % weight of dry aggregate) of both coarse and fine aggregate, for each product used in the mixture (including RAP). Use AASHTO T-84 and T-85 test methods with modifications on file in the Bituminous Office. The tolerance allowed between the Contractor's and the Department's specific gravities are G_{sb} (individual) = 0.040 and G_{sb} (combined) = 0.020.
- (9) The composite gradation plotted on a FHWA 0.45 power chart. (Federal form PR-1115)
- (10) For mixtures containing RAP include extracted asphalt binder content of the RAP with no retention factor included.
- (11) The percentage (in units of 0.1 percent) of asphalt binder material to be added, based upon the total mass of the mixture.
- (12) The temperature ranges the mixture is intended to be discharged from the plant and compacted at the roadway shall be provided by the asphalt binder supplier. Temperatures to be included are, laboratory mixing and compaction temperature ranges and maximum field mixing and compaction temperatures.
- (13) Evidence that the completed mixture will conform to all specified physical requirements as follows: Design air Voids (V_a), VMA, VFA, TSR, F/A_e (Fines to effective asphalt ratio), Density $\%G_{mm}$ at $N_{initial}$, N_{design} , and $N_{maximum}$.
- (14) When using laboratory mixture design Option 1 (2360.3B) or Option 3 (2360.3D), include the following:
 - (a) A mix design with a minimum of three different asphalt binder contents (minimum 0.4 percent between each point), with at least one point at, one above and one below the optimum asphalt binder percentage.
 - (b) The maximum specific gravity at each bitumen content. The theoretical maximum specific gravity used for percent air voids determination shall be calculated based on the average of the effective specific gravities measured by a minimum of two maximum specific gravity tests at the asphalt contents above and below the expected optimum asphalt binder content.
 - (c) The Gyratory test results for the individual and average bulk specific gravity, density, and heights, of at least two specimens at each bitumen content.

2360.3

- (d) The percent air voids in the mixture at each asphalt binder content. The percent Voids in Mineral Aggregate (VMA) at each asphalt binder content.
- (e) The fines to Effective Asphalt (F/A) ratio calculated to the nearest 0.1 percent.
- (f) Graphs showing air voids, voids in the mineral aggregate, Gmb, Gmm and unit weight vs percent asphalt binder content for each of the three asphalt binder contents submitted with trial mix.
- (g) Labeled gyratory densification tables and curves, generated from the gyratory compactor, for all points used in the mixture Submittal.

F HMA Paving Recommendation

A Department approved Paving Recommendation includes a job mix formula (JMF) from the composite gradation, aggregate component proportions, and asphalt content of the mixture. Design air voids, Voids in Mineral Aggregate, and aggregate bulk specific gravity values are indicated on the paving recommendation also. Warning limits and JMF limits will be shown for gradation control sieves, percent asphalt binder content, Air voids, and VMA.

A Department approved paving recommendation is required for all paving except material provided under 2360.7C. All submitted materials must meet aggregate and mixture design requirements before a paving recommendation is issued. The Department will verify two trial mix designs per mix type designated in the plan, per Contract at no cost to the Contractor. Additional mix designs will be verified at a cost of \$2000 per design, payable to the Commissioner of Transportation.

For city, county, and other agency projects that do not have federal or state-aid funding, the Contractor shall provide to the District Materials Laboratory a complete Project proposal including addenda, supplemental agreements, change orders, and any Plan sheets (including typical sections) that affect the mix design. The Department will not start the verification process without this information.

All test procedures and required forms are on file with the Department Bituminous Engineer. Test tolerances are shown in Table 2360-13.

F1 Initial Production Test Strip HMA Paving Recommendation

When the Contractor elects to use the 500 metric ton (550 ton) initial production, Option 3 (2360.3D), an initial JMF will be issued to provide the working range to begin production. Successful verification and validation of this JMF from the plant produced material will be made as set forth in section 2360.3D. Failure to successfully verify the mixture will result in cancellation of the JMF.

2360.4

2360.4 Mixture Quality Management

A Quality Control:

The Contractor shall provide and maintain a quality control program. A quality control program is defined as all activities, including mix design, process control inspection, sampling and testing, and necessary adjustments in the process that are related to the production of a Superpave (HMA)–pavement which meets the requirements of the specifications.

A1 Contractor Certified Plant HMA

A1a Certification Procedure

The Contractor shall:

- (1) Complete application form and request for plant inspection.
- (2) Provide a site map of stockpile locations.
- (3) Pass plant and testing facility inspection by having the Plant Inspector and Bituminous Plant Authorized Agent complete and sign the Asphalt Plant Inspection Report (TP 02142-02, TP 02143-02). By signing the Asphalt Plant Inspection Report, the HMA plant authorized agent agrees to calibrate and maintain all plant and laboratory equipment within allowable tolerances set by these specifications and the Mn/DOT Bituminous Manual.
- (4) Obtain approved mix design recommendations prior to production.

A1b Maintaining Certification

To maintain certification, the plant must produce, test, and document all certified plant asphalt mixtures in accordance with the above requirements on a continuous basis. Continuous basis means all asphalt mixtures supplied from a certified plant to any Department project with 2360 HMA mixtures must be sampled and tested in accordance with 2360 requirements. When mixtures are supplied to projects not specifying 2360 requirements for more than 3 working days the supplier shall either:

- (1) Begin testing at least 2 days before producing 2360 Asphalt mixtures for a project with 2360 requirements, or
- (2) Use the first-day sampling rate of four samples during the first 2000 metric tons (**2200 ton**) as stated in this specification.

The Contractor shall assure the plant certification procedure is performed annually after winter suspension and before producing material

for a Project with certified plant requirements. The Contractor shall recertify a plant when it is moved to a new location.

A1c Revocation of Plant Certification

2360.4

The Department Construction Engineer may revoke certification of an asphalt plant when requirements are not being met or records are falsified. The Department may revoke the Technician Certification for the individual involved.

The Department Bituminous Engineer and Department Contract Administrator will maintain a list of companies who have had their asphalt plant certification revoked.

B Quality Assurance (QA)

The Department will perform QA testing as part of the acceptance process. The Engineer is responsible for QA testing, records, and acceptance. The Engineer will accomplish the QA process by:

- (1) Conducting assurance and verification sampling and testing.
- (2) Observing sampling and tests performed by the QC personnel.
- (3) Taking additional samples at any time and any location during production.
- (4) Monitoring the required QC summary sheets and control chart.
- (5) Verification of calibrations of laboratory testing equipment.
- (6) Communicating Mn/DOT test results to the Contractor's QC personnel in a timely manner.

C Contractor's Quality Control (QC)

C1 Personnel Requirements

Along with the proposed mix design data, the Contractor shall submit to the Engineer an organizational chart listing the names and phone numbers of individuals and alternates responsible for mix design, process control administration, and inspection. The Contractor shall also post the organizational chart in the Contractor's test facility.

The Contractor's quality control organization or private testing firm shall have Certified Technicians who have met the requirements on file with the Department's Technical Certification program. Individuals performing process control testing must be certified as a Level I Bituminous Quality management (QM) Tester. Individuals performing mix design calculations or mix design adjustments must be certified as Level II Bituminous QM Mix Designer. The Contractor shall have a Certified Level II Bituminous QM Mix Designer available to make any necessary process adjustments. The Contractor shall have a minimum of one person per paving operation certified as a level II Bituminous Street Inspector.

C2 Laboratory Requirements:

The Contractor shall furnish and maintain a laboratory at the plant site or other site approved by the Engineer. The laboratory shall be furnished

with the necessary equipment and supplies for performing Contractor quality control testing in accordance with these specifications and the

2360.4

latest version of the Mn/DOT Bituminous Manual. An approved Superpave Gyratory Compactor (SGC) shall be used to conduct quality management testing. A protocol for evaluation of SGC's has been developed by the FHWA. Successful completion and acceptance of the required testing outlined in this protocol shall constitute an approved gyratory compactor. Documentation shall be submitted, when requested for approval by the Department Bituminous Engineer.

The laboratory shall be equipped with a telephone for use by the Contractor or the Engineer. A fax machine and copy machine shall be available for use by the Contractor or the Engineer at the laboratory site. The laboratory equipment shall meet the requirements listed in section 400 of the Mn/DOT Bituminous Manual and test methods described herein, including extraction capabilities. The laboratory shall be on site, calibrated, and operational prior to the beginning of production.

The Engineer shall be allowed to inspect measuring and testing devices to confirm both calibration and condition. The Contractor shall calibrate and correlate all testing equipment in accordance with the latest version of the Mn/DOT Bituminous Manual. Superpave gyratory compactors shall be calibrated, as specified by the manufacturer, a minimum of twice per year for units in permanent locations, upon arrival at portable locations and at the start of Superpave projects or when mixture bulk specific gravity values become suspect.

D Sampling and Testing:

The Contractor shall use random numbers, as indicated in the Mn/DOT Bituminous Manual 5-693.7 Table A or ASTM D3665; select locations based upon the method described in section 5 of ASTM D3665 so that all QC samples are taken at random locations. The tests for mixture properties

shall be conducted on representative portions of the mix, quartered from a larger sample of mixture taken from behind the paver, or alternate approved sampling method on file in the department Bituminous Office. The Contractor shall obtain a sample of at least 35 kg (**75 pound**). This sample may be either split in the field or transported to the test facility by a method to retain heat to facilitate sample quartering procedures. The Contractor shall store and retain Gyratory samples and companion samples for the Department for a period of 7 working days. The Contractor shall maintain these split samples in containers (labeled with companion numbers) approved by the Engineer. The Contractor shall perform QC sampling and testing according to the following schedule:

Determine the planned tonnage for each mixture to be produced during the production day. Divide the planned production by 1000. Round the number to the next higher whole number. This number will be the number of production tests required for that mixture. Split the planned production into even increments and select sample locations as described above. During production mixture volumetric property tests

2360.4

will not be required on the days when mix production is less than 100 metric tons (**110 ton**). However, when mix production is less than 100 metric tons (**110 ton**) per day on successive days, the test will be run when the accumulative tonnage on such days exceeds 100 metric tons (**110 ton**). At the start of production, double the testing frequency on the first two sets of production tests, for

Gyratory Bulk Specific Gravity and Maximum Specific Gravity (conduct four tests).

For informational purposes only:

On the first day of production, at the time the verification sample is obtained, an additional sample will be collected for hot-cold comparison of mixture properties. Hot-cold comparison testing shall be performed at the rate of one per project or one per stationary plant per year unless otherwise directed by the Engineer. The hot-cold comparison sample will be split into three representative portions. The Engineer will observe the Contractor testing the sample. One part shall be compacted immediately while still hot (additional heating maybe required to raise the temperature of the sample to compaction temperature). The second part will be allowed to cool to ambient air temperature and then be heated to compaction temperature and compacted. The third part will be allowed to cool to ambient air temperature and then be transported to the District Materials Laboratory where it will be heated to compaction temperature and compacted. From this information a calibration factor will be developed to compare the specific gravity of the hot compacted samples to reheated compacted samples. Each test will involve a minimum of two Gyratory specimens. This test may be repeated at the discretion of the Contractor or the Department.

Note: Care must be taken when reheating samples for mixture properties analysis tests. Mix samples should be reheated to 70°C (**160°F**) to allow splitting of the sample into representative fractions for the various tests. Overheating of the mixture portions to be tested for maximum specific gravity (Rice Test) may result in additional asphalt being absorbed in the aggregate.

E Production Tests:

When more than one Mn/DOT approved test procedure is available, the Contractor shall select, with the approval of the Engineer, one method at the beginning of the project and use that method for the entire project. The Contractor and Engineer may agree to change test procedures during the construction of the Project.

2360.4

| | |
|-----|--|
| E1 | Asphalt Binder Content, Percent |
| E1a | <u>Incinerator Oven</u> ⁽¹⁾ |
| | Mn/DOT Laboratory Manual Method 1853 |
| E1b | <u>Chemical Extraction</u> |
| | Mn/DOT Laboratory Manual Method 1851 or 1852 |
| E1c | <u>Spot Check</u> (Virgin Only)..... |
| |Mn/DOT Bituminous Manual 5-693.848 |
| E1d | <u>Meter Method</u> (Virgin Only) |
| | Mn/DOT Bituminous Manual |

⁽¹⁾ Incinerator Oven may not be used when the percentage of class B material exceeds 50% within the composite blend, unless a correction factor is determined by the Contractor and approved by the District Materials Engineer or designee.

| | |
|----|---|
| E2 | Gyratory Bulk Specific Gravity, Gmb (2 specimens)..... |
| | AASHTO TP4, T166, Mn/DOT modified |
| E3 | Maximum Specific Gravity, Gmm |
| |AASHTO T209, Mn/DOT modified |
| E4 | Air Voids - Individual and Isolated (Calculation) |
| | Asphalt Institute MS 2 and SP 2 |

During production of the mix, the Contractor shall monitor the volumetric properties of the Superpave mixture with a Superpave gyratory compactor. Gyratory compaction shall be conducted to N_{maximum} and calculations for percent G_{mm} at N_{initial} and N_{design} shall be determined by applying the calculated correction factor as described in the Asphalt Institute SP 2 Manual. The isolated air voids are calculated using the maximum mixture specific gravity and the corresponding bulk specific gravity from a single

test. The individual air voids are calculated from the moving average determined from the previous four test results for the maximum mixture specific gravity (G_{mm}) and the percent G_{mm} at N_{initial} , N_{design} , and N_{maximum} determined by the gyratory compactor. Mixture densification during production shall meet requirements in Table 2360-8 for percent G_{mm} at N_{initial} , N_{design} , and N_{maximum} .

Production control for percent G_{mm} at N_{design} shall conform to the control limits shown in Table 2360 - 11. Production control for percent G_{mm} at N_{initial} and N_{maximum} shall not exceed the limit shown in Table 2360-8 by more than 1.0 %. Mixture produced beyond these limits, as measured by the moving average of four tests, shall result in a cancellation of the approved Department JMF. A new mix design and Submittal that satisfies these specification criteria will be required.

2360.4

- E5 Voids Mineral Aggregate (VMA) (calculation)
..... Asphalt Institute MS 2
- E6 Gradation - Blended AggregateAASHTO T-11 & T-27
All gradations require a minus 0.075mm (#200) wash.
- E6a Plant produced Mixture:
 - (1) Field Extraction Mn/DOT Laboratory Manual Method 1854
 - (2) Hot Bins - Drybatch
 - (3) Incinerator Oven Mn/DOT Laboratory Manual Method 1853⁽¹⁾
 - (4) Chemical Extraction Mn/DOT Laboratory Manual Method 1851 or 1852

(1) If the incinerator oven is used when a mixture contains more than 50% Class B aggregate, an aggregate correction factor as approved by the District Materials Engineer shall be applied.

Testing to determine the blended aggregate gradation shall be performed every 2000 metric tons (**2,200 ton**), or portion thereof (minimum of one per day), on samples taken at the same time as the required mixture sample for a given increment.

E7 Field Moisture Damage Testing (TSR):

HMA mixture samples shall be taken at 10,000 metric tons (**11,000 ton**) increments for all mixture produced on the project. These samples shall be taken at random as directed by the Engineer. The samples shall be 50 kg (**110 pound**) minimum and split in half. The Department companion of this split shall be labeled with the date, time, project number and approximate cumulative tonnage to date. The Department companion shall be given to the Department Street Inspector or Plant Monitor immediately or delivered to the District Materials Engineer within 48 hours of sampling, as specified by the Engineer. Sampling method shall conform to one of the approved methods on file in the Bituminous Office. These samples may be tested at the discretion of the Engineer.

The following conditions will automatically require a sample to be taken and tested:

- 1. When any individual aggregate stockpile component gradation deviates more than 10% from the original gradation submitted at design as shown in 2360.3. This deviation may be determined from stockpile or extracted gradations conducted by the Contractor or the Department.
- 2. At the discretion of the Engineer.

If the TSR result fails to meet the minimum specified value as shown in 2360.2F7, the Contractor shall be notified immediately and action

2360.4

shall be taken to resolve the problem. This action may include addition of anti-stripping agent, addition of hydrated lime, or changes in aggregate components. Any costs associated with these changes shall be borne by the Contractor.

Field TSR tests shall be conducted on all mixtures according to ASTM D4867, Mn/DOT modified, specimen size shall be 150 mm (**6 inch**).

E8 Aggregate Specific Gravity (Gsb).....
.....AASHTO T84 and T85, Mn/DOT modified

Samples of all aggregate stockpiles shall be collected on each aggregate used in the production mixture, at a rate of one sample per 10,000 metric tons (**11,000 tons**) mixture produced. These samples shall be taken at random as directed by the Engineer. These representative stockpile samples shall be 40 kg (**90 pound**) of each aggregate component. Each sample shall be split in half. The Department companion shall be labeled with date, time, project number and approximate cumulative tonnage to date. The Department companion shall be given to the Department Street Inspector or Plant Monitor immediately or delivered to the District Materials Engineer within 48 hours of sampling, as specified by the Engineer.

These samples may be tested and if the results deviate beyond the tolerance specified in Table 2360-13, the results will be used for acceptance of specific gravity. Dispute resolution shall follow the procedure on file with the Bituminous Office, however any mixture placed following notification of new specific gravity values will be based upon Department results unless proven incorrect. The Contractor shall be notified when new specific gravity values become available and what impact this will have on the calculated VMA.

E9 Coarse Aggregate Angularity (CAA) ASTM D5821

CAA test results shall meet the minimum percent fractured faces as shown in Table 2360-4. Coarse Aggregate Angularity shall be determined by ASTM D - 5821 on the composite blend from aggregates used in production of hot mix asphalt. Mixtures that contain virgin aggregates may be tested from composite belt samples. Mixtures that contain RAP must be tested from extracted aggregates taken from standard production samples. The percentage of fractured faces of the composite aggregate blend less than 100% shall be tested at the following rates:

- (1) Perform two tests per day for each mixture blend for a minimum of two days and then one per day if the test samples meet CAA requirement.
- (2) If CAA crushing test results exceed 8 percent of the requirement, take one sample per day and perform one test per week.

2360.4

CAA results must be reported on the test summary sheet. Mixture placed and represented by results below the minimum requirement, as shown in Table 2360-4, will be subject to reduced payment as shown in Table 2360-12.

E10 Fine Aggregate Angularity (FAA).. ASTM C1252 Method A

FAA test results shall meet the minimum criteria shown in Table 2360-5. Fine Aggregate Angularity shall be determined by ASTM C1252 Method A on the composite blend from aggregates used in production of hot mix asphalt. Mixtures that contain virgin aggregates may be tested from composite belt samples. Mixtures that contain RAP must be tested from extracted aggregates taken from standard production samples. The percentage of uncompacted voids from the composite aggregate blend shall be tested at the following rates:

- (1) Perform two tests per day for each mixture blend for a minimum of two days and then one per day if the test samples meet FAA requirement.
- (2) If FAA test results exceed 5 percent of the requirement, take one sample per day and perform one test per week.

FAA results must be reported on the test summary sheet. Mixture placed and represented by results below the minimums, as shown in Table 2360-5, will be subject to reduced payment as shown in Table 2360-12.

E11 Moisture Content..... Mn/DOT 5-693.950

Provide a mixture with a moisture content not greater than 0.3 percent. The moisture content in the mixture shall be measured behind the paver or by an alternate approved sampling method on file in the Bituminous Office. Sampling shall be conducted by Contractor and monitored by the Inspector, on the first day of production of each course and then at the discretion of the Engineer. Sampling and testing is suggested when rain on stockpiles exceed more than 5 mm (**0.2 inch**) in a 24 hour period. The sample shall be stored in an airtight container. Microwave testing is prohibited.

Superpave HMA that exceeds 0.3 % moisture content is unacceptable. The Contractor shall take appropriate action to remove excess water from the mixture. This action may include reducing the production rate, mixing stockpile aggregates prior to placement into the feed bins, and use of covered stockpiles.

E12 Asphalt Binder Samples: Mn/DOT 5-693.920

The Contractor shall sample the first shipment of each type of asphalt binder, then sample at a rate of one per 1000000 liters (**250,000 gallons**), sample size shall be 1 L (**1 quart**). All samples shall be taken in accordance with the Mn/DOT Bituminous Manual 5-693.920. Sampling shall be conducted by Contractor and monitored by the Inspector. Promptly submit sample to the Department Materials

2360.4

Laboratory in Maplewood. The Contractor shall record sample information on an Asphalt Sample Identification Card.

F Documentation (Records):

The Contractor shall maintain control charts on an ongoing basis. Reports, records, and diaries developed during the progress of construction activities for the project, shall be filed as directed by the Engineer and will become the property of the Department. The Contractor shall:

- (1) Number test results in accordance with standard Department procedures and record on forms supplied by the Department.
- (2) Facsimile all production test results on test summary sheets to the District Materials Laboratory or other site as requested by the Engineer, by 11 AM of the day following production.
 - (2a) The following production test results and mixture information shall be included on the Department approved test summary sheet.
 1. Percent passing on sieves listed in Table 2360-2.
 2. Coarse and fine aggregate Angularity.
 3. Maximum specific gravity (G_{mm}).
 4. Bulk specific gravity (G_{mb}).
 5. Percent asphalt binder content (P_b).
 6. Calculated production air voids (V_a), percent G_{mm} at $N_{initial}$, percent G_{mm} at N_{design} , percent G_{mm} at $N_{maximum}$.
 7. Calculated voids in mineral aggregate (VMA).
 8. Composite aggregate specific gravity (G_{sb}) reflecting current proportions.
 9. Stockpile proportions in use at the time of sampling.
 10. Tons where sampled.
 11. Cumulative tons.
 12. Fines to effective asphalt ratio (F/A_e).
 - (2b) Submit copies of all failing test results to the Engineer on a daily basis.
- (3) Provide the Department with asphalt delivery invoices on a daily basis.
- (4) Provide a daily plant diary to include a description of QC actions taken (adjustment of cold feed percentages, changes in JMFs, etc.) include all changes or adjustments on the test summary sheets.
- (5) Provide weekly truck scale spot checks.

2360.4

- (6) Provide a Department approved accounting system for all mixes and provide a daily and final project summary of material quantities and types.
- (7) Furnish an automated weigh scale and computer generated weigh ticket. The ticket shall indicate project number, mix designation, pit number, Bituminous Plant Recommendation #, truck identification and tare, net mass (**weight**), date and time of loading. Any deviations from the minimum information to be provided on the computer generated weigh ticket must be approved by the Engineer in writing.
- (8) Charts and records for a mixture produced at one plant site shall be continued from contract to contract.

G Documentation (Control Charts):

The following data shall be recorded on the standardized control charts:

- (1) Blended aggregate gradation, include sieves shown in Table 2360-2 for specified mixture.
- (2) Percent asphalt binder content
- (3) Maximum specific gravity
- (4) Production air voids, percent $G_{mm} @ N_{design}$
- (5) VMA

Individual test results shall be plotted in black for each test point. A solid black line shall connect points. The moving average for each test variable shall be plotted in red starting with the fourth test. A dashed red line shall connect the points. The Department's assurance and verification test results shall be plotted with green asterisks. Specification JMF and Warning limits shall be indicated on the control charts using a green inked dotted line. The Engineer may waive the plotting of control charts.

H Control Limits

The production Air Voids and VMA limits are based upon the minimum specified requirements as shown in Tables 2360-8 and 2360-9. Gradations and Asphalt binder content limits are based upon the current Department approved JMF. Gradation control sieves include each sieve shown in Table 2360-2 with control points demarcated, as per mixture specified. The mixture production targets are listed on the approved department paving recommendation. Control limits are the target plus or minus the limits shown in Table 2360-11.

2360.4

**Table 2360-11
Control Limits (N=4)**

| Item | JMF Limits | Warning Limits |
|---|------------|----------------|
| VMA, % | - 0.3 | - 0.0 |
| Percent G_{mm} @ N_{design} / Production Air Voids | ± 1.3 | ± 1.0 |
| Asphalt Binder Content, Percent | - 0.4 | - 0.3 |
| Sieve - % Passing | | |
| 25.0 mm (1 inch), 19.0 mm (3/4 inch), 12.5 mm (1/2 inch), 9.5 mm (3/8 inch), 4.75 mm (#4) | ± 7.0 | ± 6.0 |
| 2.36 mm (# 8) | ± 6.0 | ± 5.0 |
| 0.075 mm (# 200) | ± 2.0 | ± 1.5 |

I Warning Bands

Warning Bands are defined as the area between the JMF limits and the warning limits.

J JMF Adjustment

A request for a JMF adjustment may be made to the Department Bituminous Engineer or District Materials Engineer by the Contractor. The requested change will be reviewed for the Department by a Certified Level II Bituminous QM Mix Designer. If the request meets the mixture requirements in Section 2360.2F, a revised JMF shall be issued. Each trial mixture design Submittal as described in section 2360.3A may have three JMF adjustments per mixture per project without charge. Additional JMF adjustments requested must be accompanied with a \$500 fee per each additional JMF adjustment, payable to the Commissioner of Transportation.

If a JMF change is requested for the 0.075 mm (#200) sieve, the Fines to Effective Asphalt Ratio shall be determined on the moving average from the previous four gradation tests conducted during actual production for the 0.075 mm (#200) sieve. Adjustments to conform to actual production shall not exceed the tolerances specified for the JMF limits. Regardless of such tolerances, the adjusted JMF shall be within the mixture specification gradation design broad bands shown in Table 2360-2. Should a redesign of the mixture become necessary, a new JMF shall be submitted according to the requirements of the specification. The JMF asphalt content may only be reduced if the production VMA meets or exceeds the minimum VMA design requirement for the mixture being produced.

K Corrective Action

When the moving average values trend toward the warning limits, the Contractor shall take corrective action. The corrective action shall be documented. All tests shall be part of the project files and shall be included in the moving average calculations.

2360.4

The Contractor shall notify the Engineer whenever the moving average values exceed the warning limits. If two consecutive moving average values exceed the warning limits, the Contractor shall stop production and make adjustments. Production shall only be restarted after notifying the Engineer of the adjustments made. The Contractor shall increase the testing rate to one set of production tests (2360.4E) per 450 metric tons (**500 ton**) whenever the moving average exceeds the warning limits. This includes the start-up period after shut down for consecutive averages exceeding the warning limits. The calculation of the moving average for the tests listed in 2360.4E shall not be calculated until the fourth test after the required stop in production.

Failure to stop production and make adjustments when required shall subject all mixture produced from the tonnage point the mixture exceeded the warning limit to the tonnage point when the moving average is back within the warning limits to be considered unsatisfactory. Reduced payment for unsatisfactory mixtures will be applied in accordance with Table 2360-12.

If the process adjustment improves the property in question such that the moving average after four additional tests is within the warning limits, the Contractor may continue production with no reduction in payment. If the moving average after four additional tests stays in the warning bands, the mixture will be considered unsatisfactory. Reduced payment for unsatisfactory mixtures will be applied starting from the plant tonnage the mixture exceeded the warning limit to the tonnage when the moving average is back within the warning limits in accordance with Table 2360-12.

**Table 2360-12
Payment Schedule**

| Item | Percent mixture bid price, Payment⁽¹⁾ |
|---|---|
| Coarse and Fine Aggregate Angularity ⁽²⁾ | 95 |
| Gradation | 90 |
| VMA | 85 |
| Asphalt Binder Content | 85 |
| Production Air Voids (individual) | 70 |

(1) Lowest Single Payment applies

(2) Corrective action provision does not apply, any results below minimum specified subject to this reduced payment.

2360.4

L Failing Materials

If the moving average values exceed the JMF limits, the Contractor shall stop production and make adjustments. Production shall only be restarted after notifying the Engineer of the adjustments made. The calculation of the moving average shall continue after the stop in production.

When the total production of a mixture type for the entire project requires less than four tests, single data points shall be compared to the square root of n times the warning limit, where n is the number of production tests. If the test results exceed these limits, the corrective action outlined previously will apply or if necessary, reduced payment as outlined following.

When the Contractor's testing data fails to meet specified tolerances, quality assurance and verification data shall be used in place of the Contractor's data to determine the appropriate payment factor.

L1 Moving Average Failure - Production Air Voids

Mixture placed with the individual production air voids moving average of four, exceeding the JMF limits will be considered unacceptable and shall be removed and replaced by the Contractor at the Contractor's expense. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all test results beyond the warning limits which contributed to the moving average value that exceeded the JMF limit, through the sampling point when the test result is back within the warning limits. If the Engineer decides to leave the mixture in place because of special circumstances, the mixture will be paid for at 50 percent of the contract bid price.

L2 Moving Average Failure - Percent Asphalt Binder Content, VMA, and Gradation

For properties including asphalt binder content, VMA, and Gradation, where the moving average of four exceeds the JMF limits, payment will be at 75 percent of the contract bid price for mixture provided the mixture is allowed to remain in place by the Engineer. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all test results beyond the warning limits which contributed to the moving average value that exceeded the JMF limit, through the sampling point when the test result is back within the warning limits.

L3 Individual Failure - Production Air Voids, Percent Asphalt Binder, and VMA

If the individual Quality Control tests for individual Air Voids⁽¹⁾ or percent asphalt binder content exceed twice the warning limits and the results are verified by QA tests, the material is considered unsatisfactory or unacceptable. If individual Quality Control tests for VMA exceed twice the JMF limits and the results are verified by assurance or verification tests, the material is considered unsatisfactory or

unacceptable. An investigation will be conducted to determine the extent of the problem and the amount of any price adjustments for unsatisfactory or unacceptable mixtures. Reduced payment as outlined in Table 2360-12 shall apply to all mixture represented by those results. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within the warning limits.

- (1) The daily verification sample test result shall be compared to the isolated air void determined from the verification sample taken for compliance.

L4 Individual Failure - Gradation

If the individual gradation test exceeds twice the warning limits and is outside the gradation bands listed in Table 2360-2, and is verified by QA tests, the material is considered unsatisfactory or unacceptable. An investigation will be conducted to determine the extent of the problem and the amount of any price adjustments as defined above for unsatisfactory or unacceptable mixtures. Reduced payment as outlined in Table 2360-12 shall apply to all mixture represented by those results. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within the warning limits.

L5 Coarse and Fine Aggregate Crushing Failure

If any test result for Coarse Aggregate Angularity or Fine Aggregate Angularity fail to meet minimum requirements in Tables 2360-4 and 2360-5, and the result is verified by Department tests, all material placed is subject to reduced payment as indicated in Table 2360-12. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing test until the sampling point when the test result is back within the warning limits.

M Quality Assurance (QA)

The Engineer will periodically witness the sampling and testing being performed by the Contractor. If the Engineer observes that the sampling and quality control tests are not being performed in accordance with the applicable test procedures, the Engineer may stop production until corrective action is taken. The Engineer will notify the Contractor of observed deficiencies promptly, both verbally and in writing. The Engineer will document all witnessed samples and tests. The Engineer may sample materials or final density at any time to determine quality levels. A split from these samples will be provided to the Contractor for testing. Results from these tests must be included in the control charts.

All testing and data analysis shall be performed by the Certified Level I Bituminous Quality Management (QM) Technician. Certification

2360.4

shall be in accordance with the Department's Technical Certification Program. The Department shall post a chart giving the names and telephone numbers for the personnel responsible for the assurance program.

The Engineer shall calibrate and correlate all laboratory testing equipment in accordance with the latest version of the Mn/DOT Bituminous Manual.

**Table 2360-13
Test Result Tolerances**

| Item | Allowable Difference | |
|---|---|----------------|
| Gyratory Bulk Specific Gravity (G_{mb}) | 0.030 | |
| Mixture Maximum Specific Gravity (G_{mm}) | 0.019 | |
| Fine Aggregate Angularity, uncompacted voids (U) % | 1.0 | |
| Coarse Aggregate Angularity, % fractured faces (%P) | 15 | |
| Aggregate combined blend Specific Gravity (G_{sb}) | 0.020 | |
| Tensile Strength Ratio (TSR) | Minimum Design = 80 Mn/DOT Verification = 75 | |
| Asphalt Binder Content | | |
| Meter Method, % | 0.2 | |
| Spot Check Method, % | 0.2 | |
| Chemical Extraction Methods, % | 0.6 | |
| | Same Oven | Different Oven |
| Incinerator Oven Extraction, % | 0.2 | 0.3 |
| Gradation Sieve % passing | | |
| 25.0 mm (1 inch), 19.0 mm (3/4 inch), 12.5 mm (1/2 inch), 9.5 mm (3/8 inch), 4.75 mm (#4) | 6.0 | |
| 4.75 mm (#4) | 5.0 | |
| 2.36 mm (#8) | 4.0 | |
| 0.075 mm (#200) | 2.0 | |

N Verification Testing

Verification testing shall be performed, on one set of production tests 2360.4E, excluding sections E7, E8, E11 and E12 on a daily basis. In addition to Mn/DOT's QA program, a verification sample and verification companion will be obtained on a daily basis.

The verification sample will be used to verify the requirements listed in 2360.4E and shall meet the tolerances listed in Table 2360-13. These

2360.4

include the mixture properties of G_{mm} (mixture max gravity), G_{mb} (mixture bulk gravity), production air voids (calculated isolated), asphalt binder content, VMA (calculated) and gradation. These do not include the aggregate bulk specific gravity G_{sb} or the tensile strength ratio TSR. Asphalt binder content and gradation must be determined by either extraction method 2360.4E1a or 2360.4E1b. Asphalt binder content from the verification test result must be used to determine VMA.

A verification sample is a sample which is sampled and tested by Mn/DOT to assure compliance of the Contractor's Quality Control program. This verification sample will be taken by the Department Street Inspector or Plant Monitor as determined by the Engineer. A verification companion is a companion sample, to Mn/DOT's verification sample, provided to the Contractor. The Contractor is required to test this verification companion sample. These results shall be used as part of the QC program.

This verification process is intended to identify potential sampling and/or testing problems between the Contractor and the Department. In the event verification of the aforementioned mixture properties is unsuccessful, an investigation into the source of problems will commence immediately. During the interim, until the source of error is found, the Department's test results will be used for acceptance. If the source of problem(s) is not found within 72 hours of determination that verification is not successful, the Contractor shall cease mixture production and placement until the problem is identified and resolved. The Department Laboratories will not run accelerated testing indefinitely. All efforts must be made to determine the source of the lack of proper verification of mixture properties. This process is available in flow chart format in the Bituminous Office.

N1 Testing Methodology Verification

N1a Verification and Companion test results meet tolerance

If the Department verification test results and the Contractor's verification companion test results meet the specified tolerances shown in Table 2360-13, the testing methodology has successfully been verified. Proceed to the Sampling methodology verification procedure.

N1b Verification and Companion test results do not meet tolerance

If the Department verification test results and the Contractor's verification companion test results are not within the specified tolerances listed in Table 2360-13, a determination of validity is required N1b(1). (Retests of the first material shall be conducted by Department and Contractor before proceeding to N1b(1)).

N1b(1) Verification validation

When tolerances are not met, the Department will collect the previously saved QA sample and test accordingly.

N1b(2) Verification validation (QA check meets tolerance)

2360.4

If the test results from the QA sample as compared to the QC split companion (which was already performed by the Contractor) meets the tolerances specified, the verification test is considered an exception and the QA companion result is acceptable for verification of the Contractor's QC testing methodology. Proceed to the Sampling methodology verification procedure.

N1b(3) Verification validation (QA check does not meet tolerance)

If the test result from the QA sample does not meet the tolerance specified, the original verification test is validated and the Department will continue to test the remaining QA samples until they meet the tolerance or remaining samples are all tested, whichever comes first. Acceptance for materials supplied to date, since last acceptable verification, will be made based upon the Agencies test results. An investigation shall commence immediately to determine the cause of this difference. Testing equipment, procedures, and personnel will be reviewed to determine the source of the problem.

N2 Sampling Methodology Verification

To verify the sampling methodology, the Department test results described in N1a or N1b(2) must be compared to the Contractor's most recent moving average QC test results. Validation of sampling methodology is conducted after successful completion of testing methodology verification.

N2a Verification and QC moving average meet tolerance.

If the Department verification test results in N1a or verification validation test results in (N1b(2), as compared to the Contractor's most recent moving average QC test results, are within the tolerances listed in Table 2360-13, the sampling methodology is successfully verified. Acceptance of material will be based on the Contractor's QC data.

N2b Verification and QC moving average do not meet tolerance.

If the Department verification test results in N1A or verification validation test results in (N1b(2), as compared to the Contractor's most recent moving average QC test results, are not within tolerances listed in Table 2360-13, a determination of validity is required (N1b(2).

N2b(1) Verification Validation

When tolerances are not met, the Department will collect another verification sample from subsequent production. A determination will be made whether there has been poor sampling methodology or whether the test result is an exception.

N2b(2) Verification Validation (Second verification meets tolerance vs. moving average)

If the second verification sample tested meets the tolerance specified, the first verification sample can be considered an exception. Acceptance of material will be based upon the Contractor's QC data.

2360.5

N2b(3) Verification Validation (Second verification does not meet tolerance)

If the second verification sample tested fails to meet tolerance with the Contractor's moving average, then the sampling methodology is suspect. Acceptance of material will be based upon the Department's verification test results. This will remain in effect until acceptable tolerance between the Contractor's moving average and the Department verification can be reestablished. Investigation of sampling procedures, equipment, and personnel will commence immediately.

If verification test results that are used for acceptance indicate failure to comply with volumetric or densification properties, the material placed will be subject to penalties or removal and replacement as described in Tables 2360-12 and 2360-16.

2360.5 Pavement Density

A General

All pavements will be constructed in accordance with the Maximum Density Method unless otherwise specified. Compaction of leveling layers less than 40 mm (**1.5 inches**), thin lift leveling, wedging layers, patching layers, driveways, areas which cannot be compacted with standard highway construction equipment, will be accomplished according to the Ordinary Compaction procedure described in 2360.5C.

B Maximum Density Method

All courses of plant mixed bituminous mixtures for which the Maximum Density Method is used shall be compacted to a density not less than the percentage shown in Table 2360-14. Compaction of variable thickness leveling layers (minimum thickness less than 40 mm (**1.5 inches**)), layers less than 40 mm (**1.5 inches**), wedging layers, patching layers, driveways, areas which can not be compacted with standard highway construction equipment and non-traffic areas (excluding shoulders without rolled rumble strips) will be accomplished according to the Ordinary Compaction Procedure, Subsection 2360.5C.

B1 Pavement Density Determination

The density of each lot shall be expressed as a percentage of the maximum specific gravity ($\% G_{mm}$) obtained by dividing the average bulk specific gravity for the lot by the maximum specific gravity, (maximum specific gravity basis is the average G_{mm} of QC tests done on the day that the individual lot was paved), times 100. If a new job mix formula is established, a new maximum specific gravity reflecting the new job mix formula shall be used for maximum density determination. Determination of the bulk specific gravity of the cores shall be in accordance with AASHTO T-166, Mn/DOT. For coarse graded mixtures, the Engineer may require determination of bulk specific gravity of the cores be in accordance with ASTM D1188, Mn/DOT modified. The determination of coarse and fine graded mixtures will be based on the

2360.5

percentage of material passing the 2.36 mm (#8) sieve as defined in Table 2360-9.

Compaction operations shall be completed within 8 hours of mixture placement and before core samples are obtained for density determination. Only pneumatic tired or static steel rollers are permitted for any compactive effort performed between 6 and 8 hours after mixture placement.

Compacted mixtures represented by samples or tests having deficient densities shall not be re-rolled. The Contractor shall not operate below the specified minimum density on a continuing basis. A continuing basis shall be defined as all lots in a days production failing to meet minimum density or more than 50% of the lots on multiple days which fail to meet minimum density requirements. Production shall be stopped until the source of the problem is determined and corrective action is taken to bring the work into compliance with specified minimum required density.

B2 Required Density

Density determination for wearing and non wearing courses is identified and separated by their location from the surface and is shown in Table 2360-14. Density for shoulder courses are identified by mixture placement operations. When shoulders are paved in a separate operation, density determination shall be made for the shoulder pavement separate from the mainline. Lot tonnage will be delineated for the shoulders separate from the mainline for the day paving was conducted. Shoulders paved in the same pass as the mainline will be included in the random selection of core locations within the specified lot derived from daily tonnage. The density required for shoulders, paved in the same pass as the mainline, shall conform to the mainline requirement shown in Table 2360-14. Acceptance will be based upon the entire lot.

**Table 2360-14
Required Minimum Density**

| | Wear¹ | Non wear² | Shoulders² |
|------------------------------|-------------------------|-----------------------------|------------------------------|
| Location from surface | < 100 mm (4 inch) | ≥ 100 mm (4 inch) | all |
| % Gmm | 92 | 93 | 93 |

¹ Minimum reduced by one percent on the first lift constructed over pcc pavements that have 30% or more: faulted joints & cracks and/or contain mid panel cracks. Where faults and cracks are defined as follows:

- fault > 6.35 mm (**0.25inch**)
- mid panel cracks are > 2 mm (**1/16 inch**) width and 0.6 m (**2 feet**) or more in length.

2360.5

² Minimum reduced by one percent for the first lift constructed on aggregate base, or cold recycled base courses and first lift of an overlay on a roadway with 6.35 metric ton (**7 ton**) or less spring load restriction.

B3 Lots and Core Locations

Divide the days production into equal lots as shown in Table 2360-15 and obtain three cores. Two cores will be taken from random locations selected by the Engineer. The third core, a companion core, shall be taken 0.3 meters (**1 foot**) longitudinally from either of the first two cores. The companion cores shall be given to the Department Street Inspector immediately upon completion of coring and sawing. The random locations will be determined by the use of statistically derived stratified random number tables. These will also be used for partial lots. Both transverse and longitudinal joints are subject to maximum density requirements. Randomly selected core locations may fall on the joint, in these instances, cores shall be taken tangent to the joint. Cores will not be taken within 0.3 meter (**1 foot**) of any unsupported edge. The Contractor shall be responsible for maintenance of traffic, coring, patching the core holes, and sawing the cores if necessary to the proper thickness prior to density testing.

**Table 2360-15
Description of Lots**

| Daily Production Metric Ton | (ton) English | Lots |
|--------------------------------|---------------|------|
| 0 - 545 | (0 - 600) | 1 |
| 546 - 910 | (601 - 1000) | 2 |
| 911 - 1455 | (1001 - 1600) | 3 |
| 1456 - 3275 | (1601 - 3600) | 4 |
| 3276 - 4545 | (3601 - 5000) | 5 |
| 4546 + | (5001 +) | 6 |

Cores will be taken by the Contractor and observed by the Department. The Contractor will cut pavement samples from the completed work with power equipment, and restore the surface by the end of the next working day with new, well compacted mixture without additional compensation. Failure to restore the surface within 24 hours of coring shall subject the Contractor to a fine of \$100 per working day, per lot, until the core holes are restored. Cores shall be cut using a 100 mm (**4 inch**) minimum outer diameter coring device. All samples shall be marked with the lot number, and core number or letter. The cores shall be transported to the laboratory as soon as possible to prevent damage due to improper handling or exposure to heat. These companion cores may be tested by the Inspector on Department scales or transported to the Department's Field Laboratory or District Materials Laboratory.

2360.5

If the companion cores from two consecutive days paving meet specified tolerances for bulk specific gravity, as shown in Table 2360-13, the companion core rate may be reduced to thirty percent of the lots, rounded to the nearest whole number. This reduction shall be subject to approval by the Engineer. If any companion cores fail to meet tolerance on subsequent days, the core rate shall revert to the original rate of one companion per lot.

Measure each core three times for thickness prior to saw cutting, report the average lift thickness on the core sheet. These average thicknesses will contribute to thickness compliance as described in section 2360.7C.

If the G_{mb} tolerance fails in more than 2 lots in a day of either consistently high or low differences between the companion cores then an investigation to determine the source of errors shall be conducted.

Companion cores samples shall be increased to two per lot and tested until investigation is complete and tolerances are met.

The Engineer may allow recoring of a sample only when the core has been damaged through no fault of the Contractor, either during the coring process or in transit to the laboratory.

B4 Acceptance and Payment Schedule

Density of compacted mixture shall be accepted by pavement cores on a lot basis. Core locations will be determined by the Engineer. Cores shall be tested by the Contractor and verified by the Department. Density determination will be made by the end of the next working day after placement and compaction and prior to placement of subsequent layers.

The Contractor's cores will be used for acceptance if the determined bulk specific gravity G_{mb} from AASHTO T-166, Mn/DOT modified dated 11/24/99 or ASTM D1188 is within ± 0.030 of the state companion G_{mb} value. Partial payment will be made for those lots that have an average density less than the minimum percent of G_{mm} based on Table 2360-16.

If the Department companion core test result for bulk specific gravity (G_{mb}) deviates beyond the allowable tolerance of 0.030, substitute Department companion result for Contractor's core result and then average the Department result with the non-companion result for the lot density acceptance.

If the G_{mb} tolerance fails in more than 2 lots in a day of either consistently high or low differences between the companion cores then an investigation to determine the source of errors shall be conducted.

Companion core samples shall be increased to two per lot and tested until investigation is complete and tolerances are met.

Table 2360-16
Payment Schedule For Maximum Density ⁽¹⁾

| Percent of Maximum Specific Gravity ⁽²⁾ (≤ 100 mm (4 inch) from Surface) | Percent of Maximum Specific Gravity ⁽²⁾ (>100 mm (4 inch) from Surface) | Percent Payment |
|--|--|--------------------|
| 93.6 and above | 94.6 and above | 104 ⁽³⁾ |
| 93.1 - 93.5 | 94.1 - 94.5 | 102 ⁽³⁾ |
| 92.0 - 93.0 | 93.0 - 94.0 | 100 |
| 91.0 - 91.9 | 92.0 - 92.9 | 98 |
| 90.5 - 90.9 | 91.5 - 91.9 | 95 |
| 90.0 - 90.4 | 91.0 - 91.4 | 91 |
| 89.5 - 89.9 | 90.5 - 90.9 | 85 |
| 89.0 - 89.4 | 90.0 - 90.4 | 70 |
| Less than 89.0 ⁽⁴⁾ | less than 90 | ⁽⁴⁾ |

- (1) Incentive payment is excluded when the minimum density requirement has been reduced by one percent for the first lift constructed on aggregate base, cold recycled base courses, first lift of an overlay on a roadway with a 6.35 metric ton (**7 ton**) or less spring load restriction or on the first lift constructed over pcc pavements that have 30% or more faulted joints & cracks and/or contain mid panel cracks.
- (2) In calculating the percent of maximum specific gravity, report to the nearest tenth.
- (3) The payment in this portion of the specification shall only apply if the individual production air voids, as determined from mixture production test (2360.4E) that represents the tonnage placed at that specific core location, are within - 0.5 percent of the target value.
- (4) Areas of HMA pavement shall be removed and replaced by the Contractor at their expense with mixture of the specified density and, when acceptably replaced, will be paid for at the contract unit price per ton for the original material; or the Engineer may permit the unacceptable material to remain in place with a 50 percent payment factor. The limits of the area to be removed will be determined by cored samples. The densities shall be determined at 15 m (**50 foot**) increments both ahead and back of the point of unacceptable density, and at the same offset as the original core site. If these tests indicate unacceptable density, 15 m (**50 foot**) incremental testing shall continue until a point of acceptable density is found, which is a maximum of 3.0 percent or less below the target minimum density. If the incremental testing extends into a previously accepted lot, removal of the unacceptable material will be required; however, the results of these

2360.5

tests shall not be used to recalculate the previously accepted lot density.

If a portion of the lot density is determined to be within the limits of acceptability, that area shall be compensated at the level shown in Table 2360-16. All costs incurred from additional coring and testing, resulting from unacceptable material will be paid by the Contractor. The unacceptable pavement area is computed as the product of the longitudinal limits so determined by the 15 meter (**50 foot**) cores and the full width of the paver pass, laying in the traffic lane or lanes. Shoulders shall be exempt from this calculation unless density failure occurred in the shoulder area.

Tests indicating greater than 3 percent density below the specified minimum shall be excluded from computation of the remainder of that lot's density. The remaining portion of the lot, determined to have acceptable density, shall be compensated at the specified values shown in Table 2360-16. Test results on the replacement pavement shall not be included in the original lot density computations, unless the quantity replaced represents 20 percent or greater of the lot tonnage. When the percentage of replaced material exceeds 20 percent, the replaced pavement density shall be tested and results averaged with the remaining lot results. When the percentage of replaced material is less than 20 percent of a lot, that replacement material shall have one core with one companion taken within the new pavement and accepted as outlined in Table 2360-16.

C Ordinary Compaction

This compaction method shall not be used on mainline, ramps, or loop paving. A control strip shall be used to establish a rolling pattern. This shall be used by the Contractor for the compaction of the asphalt mixture for the layer on which the control strip is constructed, or until a new control strip is constructed. The control strip requirement may be waived by the Engineer in small localized areas or other areas not conducive to its establishment.

A control strip shall be constructed at the beginning of the work on each lift of each course. Each control strip shall have an area of at least 330 m² (**395 square yard**) and shall be of the same thickness as the lift it represents. The subgrade or pavement course upon which a control strip is to be constructed shall have the prior approval of the Engineer. The control strips shall remain in place and become part of the completed work.

The materials used in the construction of the control strips shall conform to the specified requirements for the course. The materials used in the control strip shall be from the same source and of the same type as the materials used in the remainder of the course that the control strip represents.

The equipment used in the construction of the control strips shall be approved by the Engineer and shall be the same type and mass used on the remainder of the pavement course represented by the control strip. A minimum of two rollers shall be required. A rolling pattern shall be established for each roller. A pneumatic-tired roller shall be available for

2360.5

compaction operations within 24 hours after request by the Engineer. The final rolling shall be performed with a tandem steel-wheeled roller. Areas that are inaccessible to the conventional type rolling equipment shall be compacted to the required density by using trench rollers or mechanical tampers.

Construction of the control strips will be as directed by the Engineer. Compaction shall commence as soon as possible after the mixture has been spread to the desired thickness and shall continue until no appreciable increase in density can be obtained by additional rollers coverage. Densities will be determined by means of a portable nuclear testing device or approved alternate. The Contractor shall furnish documentation of the growth curve to the Engineer.

To determine when no appreciable increase in density can be obtained, two test points shall be established in the control strip on a random basis and the density at each point shall be measured by a portable nuclear device after each roller pass. Rolling shall be suspended when testing shows either: a decline of more than 2% of G_{mm} or when additional roller passes fail to increase the density. After said testing is accomplished, rolling on the remainder of that course shall be done in accordance with the pattern developed in the test strip for that roller. A separate rolling pattern and time interval shall be established for each roller.

A new control strip shall be ordered by the Engineer when:

- (a) A change in the JMF is made, or
- (b) A change in the source of material is made or a change in the material from the same source is observed.

A new control strip may be ordered by the Engineer or requested by the Contractor when:

- (a) Ten days of production have been accepted without construction of a new control strip, or
- (b) There are other reasons to believe that a control strip density is not representative of the bituminous mixture being placed.

The nuclear testing device or approved alternate shall be furnished and operated by the Contractor. The furnishing of the testing device and the operator will be considered incidental to the furnishing and placement of the bituminous mixture and shall not be compensated for separately. The device shall be calibrated according to procedures described in the Mn/DOT Bituminous Manual.

Each course shall be uniformly compacted until there is no further evidence of consolidation and all roller marks are eliminated. When this method is employed, and the quantity of mixture placed by the paver exceeds 100 metric tons (**110 ton**) per hour, at least two rollers are required for compacting the mixture placed by each paver.

C1 Rollers

2360.5

The following requirements for rollers apply only when compaction is obtained by the ordinary compaction method.

C2 Steel-Wheeled Rollers

Steel-wheeled rollers shall be self-propelled and have a minimum total mass of 7.3 metric tons (**8 tons**), or as otherwise specified in the Contract. When vibratory rollers are used, they shall produce 45 kN per meter (**3085 pounds per foot**) of width. The frequency should be at least 2400 vpm and amplitude setting low. The roller shall be capable of reversing without backlash and shall be equipped with spray attachments for moistening all rollers on both sets of wheels.

C3 Pneumatic-Tired Rollers

The pneumatic-tired roller shall have a compacting width of 1.5 m (**5 feet**) or more. It shall be so constructed that the gross mass (**weight**) is not less than 2270 kg (**5,000 pounds**) per wheel and can be varied as directed by the Engineer. The tire arrangement shall be such that full compaction will be obtained over the full width with each pass of the roller.

The roller may be self propelled or provided with suitable tractive equipment, unless the Contract specifies a certain type. If more than one roller is propelled by a single tractive unit, then that combination will be counted as a single roller unit.

C4 Trench Rollers

The trench roller shall be self propelled and have a mass (**weight**) of not less than 4400 kg per meter (**2960 pounds per foot**) of width.

C5 Mixture Temperature Controls

If compaction is obtained by the ordinary compaction method, the minimum laydown temperature in all courses (as measured behind the paver or spreading machine) of the bituminous mixture shall be in accordance with the temperature requirements of Table 2360-17.

Table 2360-17
Mixture Temperature Control

| Air Temperature | Compacted Mat Thickness, mm (A) | | | |
|-----------------|---------------------------------|-----------------------|-------------------|---------------------------------|
| | 25 mm (1 inch) | 40 mm (1-1/2 inch) | 50 mm (2 inch) | 75 mm (3 inch) or greater |
| + 0-5 (32-40) | -- | 129 (B) (265) | 124 (255) | 121 (250) |
| + 6-10 (41-50) | 130 (B) (270) | 127 (260) | 121 (250) | 118 (245) |
| + 11-15 (51-60) | 127 (B) (260) | 124 (255) | 118 (245) | 115 (240) |
| + 16-21 (61-70) | 121 (B) (250) | 118 (245) | 115 (240) | 113 (235) |
| + 22-27 (71-80) | 118 (245) | 115 (240) | 113 (235) | 113 (235) |
| + 28-32 (81-90) | 113 (235) | 110 (230) | 110 (230) | 110 (230) |
| + 33 (91+) | 110 (230) | 110 (230) | 110 (230) | 107 (225) |

(A) Based on approved or specified compacted lift thickness.

(B) A minimum of one pneumatic-tire roller shall be used for intermediate rolling unless otherwise directed by the Engineer. The Engineer may specify or modify in writing (with concurrence from the Department Bituminous Engineer) a minimum laydown temperature.

2360.6 Thickness and Surface Smoothness Requirements

A Thickness

After compaction the thickness of each course shall be within a tolerance of 6 mm (**1/4 inch**) of the thickness shown in the Plans. This thickness requirement will not apply to a leveling course. Any part of any course that is constructed to less than the minimum required thickness may be removed and replaced at the discretion of the Engineer.

On that portion of any course constructed to more than the maximum permissible thickness, the materials used in the excess mixture above that required to construct that portion of the course to the Plan thickness plus 6 mm (**1/4 inch**) will be excluded from the pay quantities and may require removal and replacement at the discretion of the Engineer.

Cores taken for density determination shall be measured for thickness also. Each core shall be measured 3 times for thickness prior to sawing. Report the average of these three measurements. Each lot's average core thickness shall be documented and submitted to the Engineer. If the average of the two Contractor cores exceed the specified tolerance, an additional two cores may be taken in the lot in question. The average of all core thickness measurements per course will be used to determine compliance with thickness specifications.

B Surface Requirements

After compaction, the finished surface of each course shall be reasonably free of open and torn sections and shall be smooth and true to

2360.6

the grade and cross section shown on the Plans with the following tolerances:

- (1) Where a leveling course is specified, it shall be constructed to within a tolerance of 15 mm (**½ inch**) of elevations and grades established by the Engineer. This requirement shall apply to the first course placed other than leveling when automatic control is used.
- (2) The surface of the non wear course and wearing course shall show no variation greater than 3 mm (**1/8 inch**) from the edge of a 3 m (**10 foot**) straightedge laid parallel to or at right angles to the centerline. Shoulder surfacing and surfacing on temporary connections and by-passes shall show no variations greater than 6 mm (**1/4 inch**) from the edge of a 3 m (**10 foot**) straightedge laid parallel to the centerline.
- (3) The transverse slope of the surface of each course, exclusive of the shoulder wearing course, shall not vary from the slope shown in the Plans by more than 0.4 percent.
- (4) The distance between the edge of each course and the established centerline shall be no less than the Plan distance nor more than 75 mm (**3 inch**) greater than the Plan distance. In addition, the edge alignment of the wearing course on tangent sections and on curve sections of 3 degrees or less shall not deviate from the established alignment by more than 25 mm (**1 inch**) in any 7.5 m (**25 foot**) section.

Any material placed outside the above described limitations shall be removed after being cut or sawed at no expense to the Department.

C General

Pavement smoothness will be evaluated on the final mainline pavement surface. Table 2360-18 shows pavement surfaces which are excluded from profilograph testing but subject to 2360.6B surface requirements.

**Table 2360-18
Profilograph Testing Exclusions**

| Pavement Surfaces Excluded From Profilograph Testing |
|--|
| Ramps, Loops, Climbing Lanes |
| Side Streets, Side Connections |
| Turn Lanes, Storage Lanes, Crossovers, By-pass Lanes |
| Shoulders |
| Acceleration, Deceleration Lanes |
| Intersections constructed under traffic |
| Sections less than 15.24m (50 feet) in length |
| Mainline paving where the posted speed is less than or equal to 70 km/h (45 miles per hour) |
| Single lift overlays over concrete. |

C1 Smoothness Requirements

Pavement smoothness requirements will be evaluated by Table 2360-19A, 2360-19B, or 2360-19C in accordance with the following unless otherwise modified.

Schedule for Identification of Pavement Sections

| Construction Type | Table |
|---|--------------|
| New construction with minimum of 3 lifts..... | 2360-19 A |
| Overlay with a minimum of 3 lifts, 40 mm (1.5 inch) minimum lift thickness..... | 2360-19 A |
| Construction with 2.4 m (8 foot) minimum shoulder separation between C&G and driving lanes minimum 3 lifts..... | 2360-19 A |
| Single lift overlays 40 mm (1.5 inch) or more in thickness that have profile milling of the original pavement..... | 2360-19 B |
| New construction with minimum 2 lifts..... | 2360-19 B |
| Construction with curb and gutter adjacent to at least one driving lane..... | 2360-19 B |
| Single lift mill (mainline and shoulder) and fill overlays..... | 2360-19 B |
| Two- lift overlays 40mm (1.5 inch) minimum lift thickness on an unmilled surface..... | 2360-19 B |
| Winter carry-over wearing course..... | 2360-19 B |
| Reclaim with 2 lifts..... | 2360-19 B |
| Uniform mill with 2 lifts..... | 2360-19 B |
| BOC with PSR(2.7-3.2) and 2 lifts..... | 2360-19 B |
| New construction with 1 lift..... | 2360-19 C |
| Single lift overlays on an unmilled surface..... | 2360-19 C |
| Construction adjacent to existing pavement..... | 2360-19 C |
| BOC with 2 lifts and PSR<2.7..... | 2360-19 C |

Note: Profile Milling: Profile milling shall consist of (1) Using a grade leveling ski control or traveling string line not less than 30 feet in length attached to the milling machine and operating parallel to its line of travel or 2) Using an erected string line, offset from and parallel to the pavement edge on one or both sides, and set parallel to the established grade for the pavement surface.

Uniform Milling: Uniform milling shall consist of specified depth milling.

C2 Measurement

Smoothness will be measured with a 7.62 m **(25 foot)** California type profilograph, which produces a profilogram (profile trace of the surface tested). One pass will be made in each lane, 2.74 m **(9 feet)** from centerline. Each lane will be tested and evaluated separately. The Engineer will determine the length in kilometers **(miles)** for each mainline traffic

2360.6

lane. The profilograph will be operated at a speed no greater than a normal walk, no greater than 6 km/hr (**4 miles per hour**). Motive power may be provided manually or by the use of a propulsion unit approved by the Engineer.

C3 Profilograph testing

The Contractor will furnish a properly calibrated and documented, 7.62 m (**25 feet**) California type profilograph. The profilograph shall be equipped with automatic data reduction capabilities unless otherwise authorized by the Engineer. Calibration documentation shall be provided to the Engineer on the first day the profilograph is used on the project. User selected profilograph settings are on file in the Bituminous Office. The Contractor will furnish a competent operator, trained in the operation and evaluation of the 7.62 m (**25 foot**) California profilograph.

All objects and foreign material on the pavement surface will be removed by the Contractor prior to testing.

The pavement surface will be divided into sections which represent continuous placement. A section will terminate 7.62m (**25 feet**) before a bridge approach panel, bridge surface, manhole or similar interruption. A day's work joint will be included in the trace with no special consideration. A section will be separated into segments of 0.1 km (**0.1 mile**). A segment will be in only one traffic lane.

A profilogram will be made for each segment of 15.24 m (**50 feet**) or more. The profilogram will include the 7.62 m (**25 feet**) at the ends of the section only when the Contractor is responsible for the adjoining surface.

End of run areas not included in the profilograph trace and any sections of pavement less than 15.24 m (**50 feet**) in length shall be checked longitudinally with a 3.028 m (**10 foot**) straight edge and the surface shall not deviate from a straight line by more than 3 mm in 3.028 m (**1/8 inches in 10 feet**).

The profile trace and index for each segment of pavement must be furnished to the Engineer within 48 hours after each days run. Identification of all bumps and dips, with signature of the Operator shall be included with the submitted trace.

For each day's run, an evaluation will be submitted to the Engineer within five days after pavement placement. The evaluation submitted shall include identification of segments which may qualify for less than 100 percent payment, segments that qualify for incentive payment and segments to be corrected.

The Contractor will be responsible for all traffic control associated with the smoothness testing.

Any portion of the project may be retested if the Engineer determines that the Contractor's test results are in question. If results are found to be inaccurate, the Contractor will be charged at a rate of \$155.34 per lane km (**\$250 per lane mile**) that is retested, with a minimum charge of \$500.00. If the results are found to be accurate, the Department will pay the

Contractor at a rate of \$155.34 per lane km (**\$250 per lane mile**) that is retested, with a minimum charge of \$500.00.

C4 Profile Index

The profilograph trace will be evaluated by the Contractor for the profile index (PI) in accordance with California Method 526 on file with the Department Bituminous Engineer. The original trace shall be provided to the Engineer for verification of the Contractor's evaluation.

A profile index shall be calculated for each segment. The index will be determined by summing the vertical deviations outside a 5 mm (**0.2 inch**) blanking band. The units of this index are mm per km (inch per mile). When there is a segment of 76.2 m (**250 feet**) or less in length, the profilograph measurements for that segment shall be added to and included in the evaluation of the adjacent section to that segment.

Bumps and dips equal to or exceeding 10.2 mm in a 7.62 m (**0.4 inch in a 25 foot**) span shall be identified separately. When the profile trace shows a successive, uninterrupted bump, dip, or dip, bump combination (up to a maximum of 3 alternating trace deviations that relate to one bump or dip on the roadway), identify and evaluate these occurrences as one event.

C5 Surface Correction

All areas represented by deviations of 28 mm (**1.1 inch**) or more, as measured by the 7.62 m (**25 feet**) profilograph, will be corrected by the Contractor.

The Contractor may elect to correct pavement segments having no more than two events or two individual bumps or dips with a vertical deviation of 10.2 mm in a 7.62 m (**0.4 inch in a 25 foot**) span. Correction of segments with more than two events or two individual bumps or dips, as defined above, will be allowed only when approved by the Engineer. The Contractor will be assessed a penalty for dips or bumps of 10.2 to 25 mm (**0.4 to 1.0 inch**) that are not corrected. Bumps and dips not corrected will also be included in the evaluation for the segment smoothness. Corrected dips or bumps will be considered satisfactory when the profilogram shows the dips or bumps are less than 10.2 mm in a 7.62 m (**0.4 inch in a 25 foot**) span.

Bump, dip, and smoothness correction work shall be for the entire traffic lane width. Pavement cross slope shall be maintained through corrective areas.

All corrective work shall be made by diamond grinding or approved equivalent, overlaying the area, by replacing the area or by inlaying. The Contractor shall notify the Engineer prior to commencement of the corrective action. If the surface is corrected by grinding, all ground areas shall be treated with an emulsified asphalt fog seal conforming to Specification 2355. If the surface is corrected by overlay, inlay or replacement, the surface correction shall begin and end with a transverse saw cut.

2360.6

If the smoothness evaluation indicates that corrective work is necessary for more than 50% of a segment, surface correction will be limited to mill and inlay (40 mm (**1 ½ inch min**)).

All corrective work shall be subject to the approval of the Engineer. After all required correction work is completed a final profile index shall be determined. Corrective work and re-evaluation will be at the Contractor's expense.

C6 Payment

The cost of certified smoothness testing and associated traffic control will be incidental to the cost of the Wear Course Mixture.

The Contractor may receive an incentive payment or be assessed a penalty based on the number of segments and the initial profile index. The total ride incentive shall not exceed 15% of the total mix price. Pay adjustments for incentives will only be based on the initial Profile Index before any corrective work has been performed. Pavement that contains corrective action for profile or bumps is not eligible for incentive pay. These payments or assessments will be based on the following schedules. The Contractor will not receive an incentive payment for ride if more than 25% of all density lots for the project (mainline paving) fail to meet minimum density requirements.

For each traffic lane, a \$900 penalty will be assessed for each bump or dip of 10.2 to 25 mm (**0.4 to 1.0 inch**) that is not corrected. The Engineer may, at his discretion, assess a penalty in lieu of requiring the Contractor to take corrective action when the profile index for a segment indicates corrective action is necessary. Penalties, based on the table the profile index is evaluated under, are as follows:

Table 2360-19A: \$560 per 0.1 km (**\$900 per 0.1 mile**)

Table 2360-19B: \$420 per 0.1 km (**\$675 per 0.1 mile**)

Table 2360-19C: \$280 per 0.1 km (**\$450 per 0.1 mile**)

Table 2360-19 A
Initial Profile Index ⁽¹⁾

| mm/km (Inches per mile) per 0.1 km segment (per 0.1 mile segment) | Dollars per Segment (Metric) | Dollars per Segment (English) |
|--|------------------------------------|-------------------------------------|
| 0 - 13.4 (0.0 - 0.8) | 190 | 300 |
| 13.5 - 25.3 (0.9 - 1.6) | 130 | 200 |
| 25.4 - 38.7 (1.7 - 2.4) | 70 | 100 |
| 38.8 - 78.9 (2.5 - 5.0) | 0 | 0 |
| 79.0 - 92.3 (5.1 - 5.8) | (70) | (100) |
| 92.4 - 105.7 (5.9 - 6.7) | (130) | (200) |
| 105.8 - 118.3 (6.8 - 7.5) | (190) | (300) |
| Over 118 (Over 7.5) | Corrective Action | Corrective Action |

- (1) If all segments in a project qualify for 100 percent payment with no grinding, the qualifying incentive payment will be increased by \$25 per metric segment and \$40 per English segment.

Table 2360-19 B
Initial Profile Index ⁽¹⁾

| mm/ km (Inches per mile) per 0.1 km segment (per 0.1 mile segment) | Dollars per Segment (Metric) | Dollars per Segment (English) |
|---|------------------------------------|-------------------------------------|
| 0 - 15.8 (0.0 - 1.0) | 145 | 225 |
| 15.9 - 31.6 (1.1 - 2.0) | 100 | 150 |
| 31.7 - 47 (2.1 - 3.0) | 55 | 75 |
| 47.4 - 110.5 (3.1 - 7.0) | 0 | 0 |
| 110.6 - 126.3 (7.1 - 8.0) | (55) | (75) |
| 126.4 - 142. (8.1 - 9.0) | (100) | (150) |
| 142.1 - 157.8 (9.1- 10.0) | (145) | (225) |
| Over 157.8 Over 10.0 | Corrective Action | Corrective Action |

- (1) If all segments in a project qualify for 100 percent payment with no grinding, the qualifying incentive payment will be increased by \$25 per metric segment and \$40 per English segment.

2360.6

Table 2360-19C
Initial Profile Index ⁽¹⁾

| mm/ km (Inches per mile) per 0.1 km segment (per 0.1 mile segment) | Dollars per Segment (Metric) | Dollars per Segment (English) |
|---|---------------------------------|----------------------------------|
| 0 - 31.6 (0.0 - 2.0) | 95 | 150 |
| 31.7-47.4 (2.1-3.0) | 65 | 100 |
| 47.5-79.0 (3.1-5.0) | 35 | 50 |
| 79.1-158.0 (5.1-10.0) | 0 | 0 |
| 158.1-189.6 (10.1-12.0) | (35) | (50) |
| 189.7-221.2 (12.1-14.0) | (65) | (100) |
| 221.3-252.8 (14.1-16.0) | (95) | (150) |
| Over 252.8 Over (16.0) | Corrective Action | Corrective Action |

⁽¹⁾ If all segments in a project qualify for 100 percent payment with no grinding, the qualifying incentive payment will be increased by \$25 per metric segment and \$40 per English segment.

2360.7 METHOD OF MEASUREMENT

A Bituminous Mixture

Bituminous mixture of each type will be measured separately by mass, based on the total quantity of material hauled from the mixing plant, with no deductions being made for the bituminous materials.

B Blank

C Asphalt Mixtures Measured by the Square Meter (Square Yard) per Specified Thickness (mm (inch)) and for Mixtures Measured by the (Square Yard inch)

Asphalt mixture of each type and for each specific course will be measured separately by area and the thickness shall be based on the planned dimension. The constructed thickness shall meet the tolerances set forth in section 2360.6A.

2360.8 COMPENSATION

A Basis of Payment:

Payment for the accepted quantities of HMA mixture used in course at the Contract prices per unit of material will be compensation in full for all costs of constructing the HMA surfacing as specified, including the costs of furnishing and incorporating any aggregate, asphalt binder, mineral filler, hydrated lime, or anti-stripping additives that may be permitted or required.

2360.8

If the Gyratory density at the recommended or established asphalt content is in excess of 2,565 kg/m³ (**160 pound per cubic feet**), payment for mixture will be calculated at the following percent of the contracted unit price.

$$\% \text{ Payment} = \{100 - [\{100 \times (\text{Gyratory Density} - 2565) / 2565\}]\}$$

$$\% \text{ Payment} = \{100 - [\{100 \times (\text{Gyratory Density} - 160) / 160\}]\}_{\text{ENGLISH}}$$

In the absence of appropriate Contract items covering shoulder surfacing and other special construction, the accepted quantities of material used for these purposes will be included for payment with the wearing course materials.

Payment for the plant mixed HMA surface will be made on the basis of the following schedule:

| <u>ItemNo</u> | <u>.Item</u> | <u>Unit</u> |
|---------------|--|-------------------------------------|
| 2360.501 | Type SP (1) Wearing Course Mixture ((3), (4)) | metric ton (ton) |
| 2360.502 | Type SP (1) Non Wearing Course Mixture ((3), (4)) | metric ton (ton) |
| 2360.503 | Type SP (1) (2) Course Mixture ((3), (4)), (5) mm (inch) thick | square meter (square yard) |
| 2360.504 | Type SP (1) (2) Course Mixture ((3), (4)) | (square yard inch) |
| 2360.505 | Type SP (1) Bituminous Mixture for Specified Purpose | metric ton (ton) |
| 2360.506 | Type SP (1) Bituminous Mixture Production | metric ton (ton) |

- (1) Aggregate Size Designation, 9.5, 12.5 or 19 as appropriate.
- (2) “Wearing” or “Non Wearing” as appropriate.
- (3) Traffic Level as per Table 2360-1.
- (4) AC binder grade designation.
- (5) Specified lift thickness.