(2360) PLANT MIXED ASPHALT PAVEMENT

Combined 2360/2350 (Gyratory/Marshall Design) Specification
December 23, 2008

This Specification requires the Contractor to provide a mix that complies with all of the design, production, and placement requirements of the specification. The Department does not make any guaranty or warranty, either express or implied, that compliance with one part of this specification guarantees that the Contractor will meet the other aspects of the specification.

All Sections titled 2360 also apply to 2350.

2360.1 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. Mixture design will be either 2360 or 2350 (gyratory or Marshall) as described in the Special Provisions through the mixture designation.

A Mixture Designations

Mixture designations for asphalt mixtures contain the following information:

(1) The first two letters indicate the mixture design type:
SP = Gyratory Mixture Design
LV = Marshall Mixture Design – Low Volume, 50 blow
MV = Marshall Mixture Design – Medium Volume, 50 blow
SM = Gyratory Mixture Design for Stone Matrix Asphalt (SMA)

(2) The third and fourth letters indicate the course:
WE = Wearing and Shoulder Wearing Course
NW = Non-Wearing Course

(3) The fifth letter or number indicates the maximum aggregate size*:
A or 4 = 12.5mm [**1/2 inch**], SP 9.5
B or 3 = 19.0mm [**3/4 inch**], SP 12.5
C or 2 = 25.0mm [**1 inch**], SP 19.0
5 = 9.5mm [**3/8 inch**], (Marshall design only)
E = See provision for SMA design
* Letter is used in gyratory designation; number is used in Marshall designation

(4) **For Gyratory Design**:
The sixth digit indicates the Traffic Level (ESAL's x 10^6)
The requirements for gyratory mixtures in this specification are based on the 20-year design traffic level of the Project expressed in Equivalent Single Axle Loads (ESAL's). The five traffic levels are shown below in Table 2360.1-A.

Table 2360.1-A
Traffic Levels

Traffic Level	20 Year Design ESAL's (1×10^6 ESAL's)
2[1]	< 1
3[2]	1 to < 3
4	3 to < 10
5	10 to ≤ 30
6	SMA

1 -- (AADT # 2300)
2 -- (2300< AADT <6000)

For Marshall Design:
The sixth and seventh digit indicate the Marshall design blows:
50 blow design for both LV and MV mixtures

(5) The last two digits indicate the air void requirement:
40 = 4.0% for SP and SM Wear mixtures
35 = 3.5% for MV Wear and Non-Wear
30 = 3.0% for LV Wear and Non-Wear and SP Non-Wear and Shoulder

(6) The letter at the end of the mixture designation identifies the asphalt binder grade:

Standard Grades	Specialty Grades
B = PG 58-28	A = PG 52-34
C = PG 58-34	H = PG 70-28
E = PG 64-28	
F = PG 64-34	
L = PG 64-22	

Ex: Gyratory Mixture Designation -- SPWEB540E (Design Type, Lift, Agg Size, Traffic Level, Voids, Binder)
Ex: Marshall Mixture Designation – LVWE35030B (Mix Type, Lift, Agg Size, Marshall blows, Voids, Binder)
Ex: SMA Mixture Designation -- SMWEE640H (Design Type, Lift, Agg Size, Traffic Level, Voids, Binder)

B **Minimum Lift thickness**
Minimum recommended paving lift thickness based on maximum aggregate size are:

Aggregate Size 5*:	Minimum Lift thickness = 12 mm [**1/2 inch**]
Aggregate Size A, 4*:	Minimum Lift thickness = 25 mm [**1 inch**]
Aggregate Size B, 3*:	Minimum Lift thickness = 40 mm [**1 ½ inch**]
Aggregate Size C, 2* (for non-wear only):	Minimum Lift thickness = 65 mm [**2 ½ inch**]

* Marshall designation

2360.2 MATERIALS

A Aggregate

A1 General

The aggregate shall consist of sound, durable particles of gravel and sand, crushed stone and sand, or combinations thereof. It shall be free of objectionable matter such as metal, glass, wood, plastic, brick, rubber, and any other material having similar characteristics. Coarse aggregate shall be free from coatings of clay and silt to the satisfaction of the Engineer.

The Contractor shall not compensate for the lack of fines by adding soil materials such as clay, loam, or silt. Overburden shall not be blended into the asphalt aggregate.

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 stockpile blended with another source, class, type or size of material.

A2 Classification

The aggregate shall conform to one of the following classifications. The class of aggregate to be used shall be the Contractor's option unless otherwise specified in the Contract.

A2a Class A

Class A aggregate shall consist of crushed igneous bedrock (specifically; basalt, gabbro, granite, gneiss, rhyolite, diorite and andosite) and rock from the Sioux Quartzite Formation. Other igneous or metamorphic rock may be used with specific approval of the Engineer. Class A materials may contain no more than 4.0% non-Class A aggregate. This recognizes the fact that some quarries may contain small pockets of non-Class A material within that source. Intentional blending or addition of non-Class A material is strictly prohibited!

A2b Class B

Class B aggregate shall consist of crushed rock from all other bedrock sources such as carbonate and metamorphic rocks. (Schist)

A2c Class C

Class C aggregate shall consist of natural or partly crushed natural gravel obtained from a natural gravel deposit.

A2d Class D

Class D aggregate shall consist of 100 percent crushed natural gravel. The crushed gravel shall be produced from material retained on a square mesh sieve having an opening at least twice as large as the Specification permits for the maximum size of the aggregate in the composite asphalt mixture. The amount of carryover (material finer than) the selected screen shall not exceed ten percent.

A2e Class E

Class E aggregate shall consist of a mixture of any two or more of the above classes of approved aggregate (A, B, and D). The use of Class E aggregate, as well as the relative proportions of the different constituent aggregates, shall be subject to the approval of the Engineer. The relative proportions of the constituent aggregates shall be accurately controlled either by the use of a blending belt approved by the Engineer prior to production or by separately weighing each aggregate during batching operations.

A2f Steel Slag

Steel slag may not exceed 25 percent of the mass of the total aggregate. Steel slag shall be free of metallics and other mill waste. Stockpiles will be accepted for use if the total expansion, determined by ASTM D4792, is less than 0.50%.

A2g Taconite Tailings (TT)

Taconite tailings shall be obtained from ore that is mined westerly of a north-south line located east of Biwabik, Mn (R15W-R16W); except that taconite tailings from ore mined in southwestern Wisconsin will also be permitted for use.

Approved taconite tailing sources are on file with the Department Bituminous Engineer.

A2h Scrap Asphalt Shingles

Scrap asphalt shingles may be included in both wear and non-wear courses to a maximum of 5 percent of the total weight of mixture. Only scrap asphalt shingles from manufacturing waste are suitable. The percentage of scrap shingles used will be considered part of the maximum allowable RAP percentage (see Table 2360.3-B2a). Refer to Section 2360.2 G1 to select a virgin asphalt binder grade (use requirements for > 20% RAP, regardless of total RAP/shingle percentage). Scrap Shingle Specifications are on file in the Bituminous Office.

A2i 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 wear and non-wear 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.

A2j Sewage Sludge Ash (SSA)

Sewage sludge ash is allowed as an aggregate source in both wear and non-wear courses to a maximum of 5 percent of the total weight of mixture. Only SSA that meets the Tier II hazard evaluation criteria as approved by Mn/DOT's Office of Environmental Services, Environmental Analysis Section, will be allowed for use in the mixture.

Approved waste incinerator ash sources are on file with the Department Bituminous Engineer.

A3 Recycled Asphaltic Pavement Materials (RAP)

The combined RAP and virgin aggregate shall meet the composite fine aggregate angularity or calculated crushed requirements (both coarse and fine aggregate) for the mixture being produced (calculated crushed allowed for Marshall design only). 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.

B Manufactured Crushed Fines (-4 material)

All Class A, B, D, and E material that passes the 4.75 mm [**#4**] screen will be considered as crushed fines.

Manufactured Crushed Fines (-4 material) from Class C Aggregate. Produce manufactured crushed fines (-4 material) from a gravel source by passing the gravel over a selected screen, 9.5 mm [**3/8 inch**] or larger, prior to mechanical crushing. The material which passes the 9.5 mm [**3/8 inch**] screen shall not be incorporated into the manufactured crushed fines but may be used as it qualifies for natural sand. The amount of carryover (material finer than) the selected screen shall not exceed ten percent.

The material retained on the 9.5 mm [**3/8 inch**] screen shall be crushed. The material that passes the 4.75 mm [**#4**] screen, after crushing, will be considered as 100% crushed fines. Material retained on the 4.75 mm [**#4**] screen after crushing will not be counted as +4 crushing until tested.

C Quality Requirements

C1 Los Angeles Rattler Test..... AASHTO T96

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 on the coarse aggregate fraction is prohibited from use in the mixture.

C2 Soundness (Magnesium Sulfate) ..... AASHTO T104

The magnesium sulfate soundness loss at 5 cycles on the coarse aggregate fraction (material retained on the 4.75 mm [**#4**]) shall not exceed the following for any individual source used within the mix: *****

a) No more than 14 % loss on the 19 mm [**3/4 inch**] to 12.5 mm [**1/2 inch**] and larger fractions.
b) No more than 18% loss on the 12.5 mm [**1/2 inch**] to 9.5 mm [**3/8 inch**] fraction.
c) No more than 23% loss on the 9.5 mm [**3/8 inch**] to 4.75 mm [**#4**] fraction.
d) No more than 18% for the composite loss. (Applies only if all three size fractions are tested).

* 1) If the composite requirement is met but one or more individual components do not, the source may be accepted if no individual component is more than 110% of the requirement for that component.

2) If each individual component requirement is met but the composite does not, the source may be accepted if the composite is no greater than 110% of the requirement.

Coarse aggregate that exceeds the requirements listed above shall not be processed for use as minus 4.75 mm [**#4**] material.

C3 Spall Materials and Lumps ..... Mn/DOT Laboratory Manual

Spall is defined as shale, iron oxide, unsound cherts, pyrite, highly weathered and/or soft phyllite and argillite (may be scratched with a brass pencil), and other materials having similar characteristics.

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.

Maximum limits for Spall and lumps, expressed as percentages by mass, are listed in Table 2360.3-B2a.

C4 Insoluble Residue Test ..... Mn/DOT Laboratory Manual

If Class B carbonate material is used in the mix, the minus 0.075 mm [**#200**] sieve size portion of the insoluble residue shall not exceed 10 percent.

D Aggregate Restrictions

Class B carbonate aggregate restrictions are specified in Table 2360.3-B2a.

E 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-E. Gradation testing shall be conducted in accordance with AASHTO T-11 (-0.075 mm [**-#200**] wash) and T-27.

Table 2360.2-E
Aggregate Gradation Broad Bands
(% passing of total washed gradation)

Sieve Size (mm [**inch**])	A or 4*	B or 3*	C or 2*	5*	E (SMA)
25.0 [**1 inch**]			100		See SMA Provisions
19.0 [**3/4 inch**]		100(1)	85-100		
12.5 [**1/2 inch**]	100(1)	85-100	45-90		
9.5 [**3/8 inch**]	85-100	35-90	-	100	
4.75 [**#4**]	25-90	30-80	30-75	65-95	
2.36 [**#8**]	20-70	25-65	25-60	45-80	
0.075 [**#200**]	2.0-7.0	2.0-7.0	2.0-7.0	2.0-7.0	

*Marshall Designation

(1) The gradation broadband for the maximum aggregate size may be reduced to 97% passing for mixtures containing RAP, when the oversize material is suspected to come from the RAP source. The virgin material must remain 100% passing the maximum aggregate sieve size.

F 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, at the unit price specified in the proposal. The Department will not compensate the Contractor for additives incorporated at the Contractor's option.

Additives will 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.

F1 Mineral Filler 3145

F2 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.

F3 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 alter the asphalt binder, such that it fails to meet the Performance Grade (PG) requirements, shall not be used. Liquid anti-strip may be added by the supplier at the refinery or by the Contractor at the plant site. The company/supplier adding the additive shall be responsible for testing the binder/additive blend to ensure compliance with the AASHTO M 320, Standard Specification for Performance Graded Asphalt Binder. No paving will be allowed until the asphalt binder/additive blend has been tested and results show that binder/additive blend properties meet the criteria in Section 2360.2G. The testing shall be done in accordance with a Mn/DOT approved Asphalt Binder QC Plan. Requirements for the Asphalt Binder QC Plan are on file in the Bituminous Office.

The following requirements for HMA mixture and asphalt binder must also be met when liquid anti-strip is added at the HMA plant site.

Mixture Requirements at Design:

1) The Contractor must design the mixture with the same asphalt binder that will be supplied to the plant site. (Both Laboratory Mixture Design (Option 1) and Modified Mixture Design (Option 2).
2) The Contractor must provide documentation with either design option that includes Tensile Strength Ratio results with the liquid anti-strip dosed at the optimal rate. Documentation must include verification the binder/additive blend meets AASHTO M 320 at the optimal dose rate.

Contractor Production Testing Requirements for Asphalt Binder/Liquid Anti-Strip Blend:

1) The Contractor shall, on a daily basis, sample and test the asphalt binder/anti-strip blend. Testing of the blend can be by viscosity, penetration, or dynamic shear rheometer (DSR). When a polymer modified asphalt binder is specified, the Contractor shall use the DSR as the daily QC test.
2) The Contractor shall, on a weekly basis, send the Engineer and Mn/DOT Chemical Laboratory Director a weekly QC report summarizing the results of the daily testing as required in number 1.
3) The Contractor shall, on a bi-weekly basis, test the binder/anti-strip blend to ensure compliance with the AASHTO M 320, Standard Specification for Performance Graded Asphalt Binder (minimum 1/project). Test results shall be sent to the Engineer and Mn/DOT Chemical Laboratory Director.
4) In addition to the sampling requirements listed above, the Contractor shall obtain asphalt binder/anti-strip blend field verification samples according to 2360.4 E12.

Liquid Anti-Strip Additive Metering System:

1) The metering system shall include a liquid anti-strip flow meter in addition to an anti-strip pump. The flow meter shall be connected to the liquid anti-strip supply to measure and display only the anti-strip being fed to the asphalt binder.
2) The meter readout shall be positioned for convenient observation.
3) There shall be a means provided for comparing the flow meter readout with the calculated output of the anti-strip pump. See number 7.
4) The system shall display in units of liters [**gallons**] to the nearest liter [**gallon**] or in units of metric tons [**tons**] to the nearest 0.001 metric tons [**0.001 tons**], the accumulated anti-strip quantity being delivered to the mixer unit.
5) The system shall be calibrated and adjusted to maintain an accuracy of $\pm$ one percent error.
6) Calibration shall be required for each plant set-up prior to production of mixture.
7) The Engineer may require, on a daily basis, the Contractor "stick" the anti-strip tank at the end of the days production to verify anti-strip usage quantities.
8) The system shall provide for a convenient method for sampling the binder/anti-strip after blending has occurred.
9) Alternative blending and metering systems must be pre-approved by the Engineer

F4 Coating and Anti-Stripping Additive 3161

G Asphalt Binder Material..... AASHTO M 320

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 the Department Bituminous Engineer approves it. The Contractor shall not use petroleum distillates such as fuel oil, diesel fuel or other fuels in the asphalt tanks. A statement shall be provided by the supplier for recommended laboratory mixing and compaction temperatures and field maximum mixing and compaction temperatures.

G1 Asphalt Binder Selection Criteria for All Mixtures with RAP

Overlay	Specified PG Asphalt Binder Grade	Virgin Asphalt Binder Grade to be used with RAP	
		≤ 20% RAP	> 20% RAP
	All PG Grades	No grade adjustment	No grade adjustment

New Construction (1)	Specified PG Asphalt Binder Grade	Virgin Asphalt Binder Grade to be used with RAP	
		≤ 20% RAP	> 20% RAP
	52-34	52-34	52-34
	58-28	58-28	58-28
	58-34	58-34	Not allowed *
	64-28	64-28	64-28
	64-34	64-34	Not allowed *
	Other PG Grades	No grade adjustment	Not allowed *

* When approved by the Engineer, the virgin asphalt binder grade can be selected by using the blending chart procedure on file in the Bituminous Office. Mn/DOT may take production samples for information/verification of compliance with a specified asphalt binder grade.

(1) Includes cold inplace recycle, reclaiming, and reconstruction.

2360.3 MIXTURE DESIGN

A Mixture Design General

The asphalt mix may be designed using one of the following two Contractor trial mix design options as described in 2360.3B and 2360.3D. Review of mixture designs will be performed in the District Materials Laboratory where the Project is located. All mixture design test results, documentation, aggregate material samples, and mixture samples, as required by the trial mix design option, shall be submitted to the District Materials Laboratory where the Project is located (Department Bituminous Engineer in Metro area). Unless otherwise authorized by the District Materials Engineer, the addition of aggregates and materials not included in the original mixture submittal is prohibited.

It is the Contractor's responsibility to design a Marshall mixture in accordance with the most current AASHTO T-245, the Asphalt Institute's Mix Design Methods for Asphalt Concrete MS-2, and the Mn/DOT Laboratory Manual such that it meets the requirements of this specification.

For Marshall design, the design air void content of the mixture is dependent on the mixture type, regardless of the location in the pavement structure. Design air void content for LV and MV mixtures is 3.0% and 3.5%, respectively.

It is the Contractor's responsibility to design a gyratory mixture in accordance with the most current AASHTO T-312, the Asphalt Institute's Superpave Mix Design Manual SP-2 (2-hour short term aging period is used for volumetric), and the Mn/DOT Laboratory Manual such that it meets the requirements of this specification.

B Laboratory Mixture Design (Option 1)

To verify Laboratory Mixture Design compliance with these specifications, the Contractor shall submit mixture design test results and documentation as described in Section 2360.3C and the materials described below to the District Materials Laboratory where the Project is located (Department Bituminous Engineer in Metro area). The District Materials Engineer (Department Bituminous Engineer) will issue a Mixture Design Report when the mixture design has been successfully verified.

B1 Aggregate sample

At least 15 working days prior to the start of asphalt production, the Contractor shall submit aggregate samples for quality testing. A 35 kg [**80 pound**] sample of representative aggregate retained on the 4.75 mm sieve [**#4**] and a 15 kg [**35 pound**] sample of material passing the 4.75 mm sieve [**#4**] shall be submitted to the District Materials Laboratory where the Project is located (Bituminous Engineer in Metro area). In addition to the preceding requirements the Contractor shall also submit a 35 kg [**80 pound**] sample of representative RAP material when the mixture includes recycled asphalt pavement. The Contractor shall provide 24 hour notice of intent to sample aggregates. 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. The Contractor shall retain a companion sample of equal size until a Mixture Design Report is issued. Quality requirements are defined in Section 2360.2C.

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. Dispute resolution procedures for aggregate qualities are on file in the Bituminous Office.

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 be used in the mixture. The JMF will be reviewed in the District Materials Laboratory where the Project is located (Department Bituminous Engineer in Metro area). A Level II Quality Management mix designer must sign the proposed JMF. For each JMF submitted, the Contractor shall include test data to demonstrate conformance to mixture properties as specified in Table's 2360.3-B2b and 2360.3-B2c. The proposed JMF shall be submitted on forms approved by the Department. In addition, the Contractor shall submit an uncompacted mixture sample plus briquettes compacted at the optimum asphalt content and required compactive effort conforming to the JMF for laboratory examination and evaluation. Mixture sample size and number of compacted briquettes are as follows:

Table 2360.3-B2
Mixture Sample Requirements

Item	Gyratory Design	Marshall Design
Un-compacted Mixture Sample Size	30 Kg [**75 pounds**]	18 Kg [**40 pounds**]
Number of compacted briquettes	2	3

B2a Mixture Aggregate Requirements

The aggregate fractions shall be sized, graded, and combined in such proportions that the resulting mixture will meet the requirements listed in Section 2360.2-E and Table 2360.3-B2a shown below.

Table 2360.3-B2a
Mixture Aggregate Requirements

Aggregate Blend Property	Traffic Level 2& LV	Traffic Level 3 & MV	Traffic Level 4	Traffic Level 5	SMA T. Level 6
20 year Design ESAL's	<1 million	1 - 3 million	3 - 10 million	10 – 30 million	See SMA Provisions
Coarse Aggregate Angularity (ASTM D5821) (one face / two face), %- Wear (one face / two face), %- NonWear	 30/- 30/-	 55 / - 55 / -	 85 / 80 60/ -	 95 / 90 80 / 75	-
Fine Aggregate Angularity (FAA) (AASHTO T304, Method A) %- Wear %-Non-Wear	 40(2) 40(2)	 42(1) 40(1)	 44 40	 45 40	-
Flat and Elongated Particles, max(2) % by weight, (ASTM D 4791)	-	10 (5:1 ratio)	10 (5:1 ratio)	10 (5:1 ratio)	-
Clay Content(2) (AASHTO T 176)	-	-	45	45	-
Total Spall in fraction retained on the 4.75mm [**#4**] sieve – Wear Non-Wear	 5.0 5.0	 2.5 5.0	 1.0 2.5	 1.0 2.5	-
Maximum Spall Content in Total Sample – Wear Non-Wear	 5.0 5.0	 5.0 5.0	 1.0 2.5	 1.0 2.5	-
Maximum Percent Lumps in fraction retained on the 4.75mm [**#4**] sieve	0.5	0.5	0.5	0.5	-
Class B Carbonate Restrictions					
Maximum% -4.75mm [**-#4**] Final Lift/All other Lifts	 100/100	 100/100	 80/80	 50/80	-
Maximum% +4.75mm [**+#4**] Final Lift/All other Lifts	 100/100	 100/100	 50/100	 0/100	-
Gyratory Max. allowable RAP percentage(3) Wear / Non Wear	 30/40	 30/30	 30/30	 30/30	
Marshall Max. allowable RAP percentage(4) Wear / Non Wear	 30/40	 30/30			

(1) For Marshall design, the Contractor may determine –4 crushing by either FAA of uncompacted voids or calculation of crush from the composite blend. The choice must be made prior to start of production. Manufactured crushed fines requirement is 25%. RAP sand will be considered 50% crushed if the FAA equals or exceeds 40, and 100% crushed if the angularity index equals or exceeds 45.

(2) Not applicable under Marshall design.

(3) When shingles are included as part of the allowable RAP percentage in Traffic Level 2, 3, 4, or5 mixtures the ratio of added new asphalt binder to total asphalt binder shall be 70% or greater ((added binder/total binder) x 100 >= 70). A minimum of 1 spotcheck per day per mixture blend is required to determine new added binder.

(4) When shingles are included as part of the allowable RAP percentage in LV and MV mixtures the added new asphalt shall be 3.5% or greater. A minimum of 1 spotcheck per day per mixture blend is required to determine new added binder.

B2b Mixture Requirements

Mixture evaluation will be based on the trial mix tests and the corresponding requirements listed in Table 2360.3-B2b and Table 2360.3-B2c.

Table 2360.3-B2b
Mixture Requirements

	Traffic Level 2	Traffic Level 3	Traffic Level 4	Traffic Level 5	SMA T. Level 6
20 year Design ESAL's	< 1 million	1 - 3 million	3 - 10 million	10 – 30 million	See SMA Provisions
Gyratory Mixture Requirements					
Gyrations for N_{design}	40	60	90	100	-
%Air Voids at N_{design}, -- Wear %Air Voids at N_{design}, -- Non-Wear & All Shoulder	4.0 3.0	4.0 3.0	4.0 3.0	4.0 3.0	-
Tensile Strength Ratio [(1)], min%	75[(2)]	75[(2)]	80[(3)]	80[(3)]	-
Fines/Effective Asphalt	0.6 – 1.2	0.6 – 1.2	0.6 – 1.2	0.6 – 1.2	-
VFA, % -- Wear- 4.0% Voids Non-Wear & All Shoulder- 3.0% Voids	65 - 78 70 – 83	65 - 78 70 - 83	65 - 76 70 - 82	65 - 76 70 - 82	
Marshall Mixture Requirements	LV	MV			
Marshall Blows	50	50	-	-	-
Air Voids, %	3.0	3.5	-	-	-
Tensile Strength Ratio [(1)], min%	70[(4)]	70[(4)]			
Stability, minimum N [**lb f**]	5000 [**1125**]	6000 [**1350**]			
Fines/Effective Asphalt Wear Non-Wear	0.6 - 1.30 0.6-1.40	0.6 - 1.30 0.6-1.40	-	-	-

(1) See Section 2360.4 E9. Use 150mm [**6 inch**] specimens for gyratory and 100mm [**4 inch**] specimens for Marshall design.
(2) Mn/DOT Min = 65, [(3)] Mn/DOT Min = 70, [(4)] Mn/DOT Min = 60

B2c VMA Criteria

The voids in mineral aggregate (VMA) of the mixture at design and during production shall meet the minimum criteria as shown in Table 2360.3-B2c at the specified compaction level. VMA shall be calculated according to the procedures outlined in Asphalt Institutes SP-2 or MS-2 manual. VMA is a design and acceptance/process control requirement.

Table 2360.3-B2c
Voids in Mineral Aggregate (VMA) Mixture Requirements

Gradation	Fine Mixture % Pass 2.36 mm [**#8**]	VMA Minimum	Coarse Mixture % Pass 2.36 mm [**#8**]	VMA Minimum
A or 4*	> 47	15.0**	≤ 47	14.5**
B or 3*	> 39	14.0	≤ 39	13.5
C or 2*	> 35	13.0	≤ 35	12.5
5*	-----	15.0**	-----	-----
E	See SMA Provisions			

*Marshall designation.
**For LV 4 and LV 5 mixes lower VMA requirements by 0.5%

B3 Tensile Strength Ratio sample

Mixture or briquettes 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 Section 2360.3C. One of

the following options may be used to verify that the tensile strength ratio (TSR) meets the requirements in Table 2360.3-B2b.

Option A) The Contractor will batch material at the design proportions including optimum asphalt. Immediately (before curing) split the sample and allow samples to cool to room temperature. Submit 35 kg [**77 pounds**] of mixture to the District Materials Laboratory for curing and test verification. Both groups will use a two (2) hour cure time (± 15 minutes) at 144°C [**290°F**] and follow procedures in ASTM D 4867-92, Mn/DOT modified as defined in the Mn/DOT Laboratory Manual.

Option B) The Contractor batches, cures (as indicated in option A), compacts, and submits briquettes and uncompacted mixture as specified below.

Table 2360.3-B3
Option B Mixture Requirements

Item	Gyratory Design	Marshall Design
Un-compacted Mixture Sample Size	8,200 g	8,200 g
Number of compacted briquettes[(1)]	6	9
Compacted briquette air void content	6.5 – 7.5%	6.0 – 8.0%

[(1)] 150mm [**6 inch**] specimens for gyratory design
100mm [**4 inch**] specimens for Marshall design

B4 Aggregate Specific Gravity..... AASHTO T84 and T85, Mn/DOT Modified

The Contractor shall determine the specific gravity of all aggregate used in the mixture.

C Documentation

Each proposed JMF submitted for review under Section 2360.3B 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 project number of the Contract on which the mixture will be used.
(3) The design traffic level and the design number of gyrations.
(4) 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..
(5) The percentage in units of 1 percent (except the 0.075 mm sieve [**#200**] 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.
(6) 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).
(7) The composite gradation based on (5) and (6) above. Note: Include virgin composite gradation based on (6) and (7) above for mixtures containing RAP.
(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 Mn/DOT modified as defined in the Mn/DOT Laboratory Manual. The tolerance allowed between the Contractor's and the Department's specific gravities are G_{sb} (individual) = 0.040 [+4 AND -4] and G_{sb} (combined) = 0.020.
(9) The composite gradation plotted on a FHWA 0.45 power chart. (Federal form PR-1115)
(10) The test results from the composite aggregate blend at the proposed JMF proportions indicating compliance with Coarse Aggregate Angularity, Fine Aggregate Angularity, and Flat and Elongated as shown in Table 2360.3-B2a.

(11) For mixtures containing RAP include extracted asphalt binder content of the RAP with no retention factor included.

(12) The percentage (in units of 0.1 percent) and PG grade of asphalt binder material to be added, based upon the total mass of the mixture.

(13) Each trial mixture design shall include the following:

(a) 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 asphalt binder 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 test results for the individual and average bulk specific gravity, density, and heights, of at least two specimens at each asphalt binder content. For Marshall design include the test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimens at each asphalt binder content.

(d) The percent air voids in the mixture at each asphalt binder content.

(e) The percent Voids in Mineral Aggregate (VMA) at each asphalt binder content.

(f) The fines to Effective Asphalt (F/A) ratio calculated to the nearest 0.1 percent.

(g) TSR results at the optimum asphalt binder content.

(h) 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.

(i) Evidence the completed mixture will conform to design air voids (V_a), VMA, VFA (gyratory), TSR, F/A_e (Fines to effective asphalt ratio).

(j) For gyratory design, the documentation shall also include labeled gyratory densification tables and curves generated from the gyratory compactor for all points used in the mixture submittal.

(14) Optional Add-Rock/Add-Sand Provisions

If the Contractor chooses 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 Section 2360.3B1. The Contractor shall provide mix design data for two additional 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. The following information will be reported for each of these two points:

(a) The maximum specific gravity (average of two tests).

(b) The test results for the individual and average bulk specific gravity, density, and height of at least two specimens at the optimum asphalt binder content. For Marshall design include the test results for the individual and average bulk specific gravity, density, height, stability, and flow of at least three specimens at the optimum asphalt binder content.

(c) The percent air voids in the mixture for each point.

(d) The Fines to Effective Asphalt ratio calculated to the nearest 0.1 of a percent.

(e) Coarse and Fine Aggregate crushing counts

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 briquettes are required for these two additional points.

D Modified Mixture Design (Option 2)

The Contractor shall submit mixture design test results and documentation as described in Section 2360.3C to the District Materials Laboratory where the Project is located (Department Bituminous Engineer in Metro area) to verify compliance with these specifications. The District Materials Engineer (Department Bituminous Engineer) will issue a Mixture Design Report when the mixture design has been successfully verified. Mixture submittal is not required. The Contractor may use this option if **all** of the following conditions are met:

a) The aggregates must have been tested for and meet all applicable quality requirements in the current construction season.

b) The Level II mix designer submitting the mixture design must have a minimum of 2 years experience in mixture design.

c) The Contractor and his representatives cannot have violated the requirements of 1512 Unacceptable and Unauthorized Work relating to mixture design or mixture production within the last 12 month period.

D1 JMF Submittal

At least 2 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. A Level II Quality Management mix designer must sign this proposed JMF. For each JMF submitted, the Contractor shall include documentation as outlined in Section 2360.3C to demonstrate conformance to mixture properties as specified in Table 2360.3-B2b and 2360.3-B2c. The proposed JMF shall be submitted on forms approved by the Department.

D2 Initial Production Test Verification

At the start of production, the testing frequency for the first 1,800 metric tons [**2,000 tons**] of each mix type shall be as specified in Table 2360.4-D.

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.

The Department shall take a mix verification sample within the first four samples at the start of production of each mix type.

D3 Tensile Strength Ratio sample

See Section 2360.4E9

D4 Marshall Stability (Marshall Design Only)

On the first day of production, for each different mix design, at the same time the verification sample is obtained, an additional sample shall be obtained for Department evaluation of Marshall stability. This sample may be tested at the discretion of the District Materials Engineer. The Contractor is not required to test stability on production mixture.

If the Marshall stability fails to meet the minimum requirements as listed in Table 2360.3-B2b the Contractor shall stop production immediately. The Contractor will be required to submit a revised mix design, with bituminous mixture at optimum asphalt content, to the District Materials Laboratory. If the mixture meets the minimum stability requirement production may be resumed.

If the stability fails the second time, the Mix Design Report will be revoked. The Contractor will then be required to submit a new mix design according to Laboratory Mixture Design 2360.3B, Option 1. A new Mix Design Report will be issued upon successful verification of the new mixture design submittal.

E Mixture Design Report

A Mixture Design Report consists of the JMF (Job Mix Formula). The JMF includes composite gradation, aggregate component proportions, asphalt binder content of the mixture, design air voids, Voids in Mineral Aggregate, and aggregate bulk specific gravity values. JMF limits will be shown for gradation control sieves, percent asphalt binder content, air voids, and VMA. Issuance of a Mixture Design Report confirms the mixture has been reviewed for and meets volumetric properties only. No guaranty or warranty, either express or implied, is made regarding placement and compaction of the mixture.

A Department reviewed Mixture Design Report is required for all paving except for small quantities of material provided under Section 2360.5H. All submitted materials must meet aggregate and mixture design requirements before a Mixture Design Report is issued. The Department will review 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, 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.

2360.4 MIXTURE QUALITY MANAGEMENT (Quality Control/Quality Assurance)

A Quality Control (QC)

The Contractor shall provide and maintain a quality control program for HMA production. 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 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 forth in these specifications, Standard Specifications for Construction, and the Mn/DOT Bituminous Manual.

(4) Obtain a Mixture Design Report 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 asphalt mixtures must be sampled and tested in accordance with 2360 requirements and the Schedule of Materials Control.

The Contractor shall assure the plant certification procedure is performed annually after winter suspension and before producing material for a Project. In addition, a first-day sampling and testing frequency rate as stated in Table 2360.4-D shall be followed.

The Contractor shall recertify a plant when it is moved to a new location or a previously occupied 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 Quality 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 charts.
(5) Verifying calibration of laboratory testing equipment.
(6) Communicating Mn/DOT test results to the Contractor's QC personnel in a timely manner (See 2360.4M and 2360.4N).
(7) Ensuring Independent Assurance Sampling and testing requirements are met.

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 a current organizational chart and if required by the Engineer, post a daily roster of individuals performing QC testing 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. The laboratory equipment shall meet the requirements listed in Section 400 of the Mn/DOT Bituminous Manual, Mn/DOT Lab Manual, and these specifications, including having extraction capabilities. The laboratory shall be calibrated and operational prior to the beginning of production. In addition to the requirements listed above, 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 Engineer may waive the requirement to have a fax machine available at the laboratory site if transfer of data and test results can be accomplished through electronic transmittal (email). The laboratory shall also include a computer and printer. The computer shall have the following minimum requirements: 1) Intel based with either Celeron or Pentium IV processor with a minimum processor speed of 1.8 MHZ. 2) CD writer with CD/RW capability and a minimum write speed of 16x. 3) Windows 2000 or Windows XP with Microsoft Excel version 97 or newer. The printer must be able to print control charts.

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 and Mn/DOT Lab Manual. Records of calibration for each piece of testing equipment shall be kept in the same facility as the equipment.

D Sampling and Testing

The Contractor shall ensure that all QC samples are taken at random locations. Random number generation and determination of random sample location shall be consistent with the Mn/DOT Bituminous Manual Section 5-693.7 Table A or Section 5 of ASTM D3665. The Engineer may approve alternate methods of random number generation.

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 when approved by the Engineer, an alternate sampling location. The procedure for truck box sampling, an alternate sampling location, is on file in the Bituminous Office. When an alternate sampling location is approved and used by the Contractor, the daily verification sample must still be taken from behind the paver.

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 mixture bulk 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. 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. Required production tests are listed in Table 2360.4-E. Split the planned production into even increments and select sample locations as described above. If actual tonnage exceeds planned tonnage additional tests may be required. During production, mixture volumetric property tests will not be required when mix production is less than 270 metric tons [**300 tons**]. However, production tests will be required when the accumulative tonnage on successive days exceeds 270 metric tons [**300 tons**].

At the start of production, the testing frequency for the first 1800 metric tons [**2,000 tons**] of each mix type shall be as follows:

Table 2360.4-D
Production Start-Up Testing Rates

Production Test	Testing Rates	Test Reference	Section
Bulk Specific Gravity	1 test per 450 metric tons [**500 tons**]	AASHTO T312,T166 Mn/DOT modified	2360.4E2
Maximum Specific Gravity	1 test per 450 metric tons [**500 tons**]	AASHTO T209 Mn/DOT modified	2360.4E3
Air Voids (calculated)	1 test per 450 metric tons [**500 tons**]	AASHTO T269, T312	2360.4E4
Asphalt Content	1 test per 450 metric tons [**500 tons**]	Bit & Lab Manual	2360.4E1
VMA (Calculated)	1 test per 450 metric tons [**500 tons**]	AI MS 2 & SP 2	2360.4E5
Gradation	1 test per 900 metric tons [**1000 tons**]	AASHTO T11, T27, T30Mn/DOT modified	2360.4E6
Coarse Aggregate Angularity	1 test per 900 metric tons [**1000 tons**]	ASTM D5821	2360.4E7
Fine Aggregate Angularity (FAA)(1)	1 test per 900 metric tons [**1000 tons**]	AASHTO T304, Method A	2360.4E8

(1) Marshall design allows -4.75mm [**-#4**] manufactured crushed fines calculation per Mn/DOT Bituminous Manual

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.

Table 2360.4-E
Production Sampling and Testing Rates

Production Test	Sampling/Testing Rates	Test Reference	Section
Bulk Specific Gravity	Divide the planned production by 1000. Round the number to the next higher whole number.	AASHTO T312, T245 T166 Mn/DOT mod	2360.4E2
Maximum Specific Gravity	"	AASHTO T209 Mn/DOT modified	2360.4E3
Air Voids (calculated)	"	AASHTO T269, T312	2360.4E4
Asphalt Content	"	Bit & Lab Manual	2360.4E1
VMA (Calculated)	"	AI MS 2 & SP 2	2360.4E5
Gradation	1 gradation per 1,800 metric tons [**2,000 tons**], or portion thereof (minimum of one per day)	AASHTO T11, T27, T30Mn/DOT modified	2360.4E6
Coarse Aggregate Angularity	2 tests/day for a minimum of 2 days, then 1 per day if CAA is met. If CAA >8% of requirement, 1 sample/day but test 1/week.	ASTM D5821	2360.4E7
Fine Aggregate Angularity (FAA)(1)	2 tests/day for a minimum of 2 days, then 1 per day if FAA is met. If FAA >5% of requirement, 1 sample/day but test 1/week.	AASHTO T304, Method A	2360.4E8
TSR	1st sample at 5,000 tons or by second day of production, then sample at every 18,000 metric tons [**20,000 tons**]	ASTM D4867 Mn/DOT modified	2360.4E9
Aggregate Specific Gravity	When directed by the Engineer	AASHTO T84 & T85, Mn/DOT modified	2360.4E10
Mixture Moisture Content	Daily unless exempted by Engineer	Mn/DOT 5-693.950	2360.4E11
Asphalt Binder	Sample 1st load (each grade) then 1 per 1,000,000 liter [**250,000 gallon-sample size 1 quart**.]	Mn/DOT 5-693.920	2360.4E12

(1) Marshall design allows -4.75mm [**-#4**] manufactured crushed fines calculation per Mn/DOT Bituminous Manual

E1 **Asphalt Binder Content** [(2)]

(a) Spot Check (Virgin only)..... Mn/DOT Bituminous Manual
(b) Incinerator Oven [(1)] ..... Mn/DOT Laboratory Manual Method 1853
(c) Chemical Extraction ..... Mn/DOT Laboratory Manual Method 1851 or 1852
(d) Meter Method (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.
(2) For Traffic Level 4 and 5 mixtures that include shingles as part of the allowable RAP percentage a minimum of 1 spotcheck per day per mixture blend is required to determine new added asphalt binder (See footnote 3 of Table 2360.3-B2a).

E2 **Marshall Bulk Specific Gravity, G_{mb} (3 specimens).....AASHTO T166, Mn/DOT Modified, or**

E2a **Gyratory Bulk Specific Gravity, G_{mb} (2 specimens) .....AASHTO T312, T166, Mn/DOT Modified**

E3 **Maximum Specific Gravity, G_{mm}..... AASHTO T209, Mn/DOT Modified**

E4 **Air Voids - Individual and Isolated (calculation).....AASHTO T269, T312**

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

For gyratory design, compaction shall be conducted to N_{design}, as shown in Table 2360.3-B2a, for the specified Traffic Level.

E5 **Voids Mineral Aggregate (VMA) (calculation) ..... Asphalt Institute MS-2, SP-2**

E6 **Gradation - Blended Aggregate..... AASHTO T-11, T-27, and T-30 (all Mn/DOT modified)**

Testing to determine the blended aggregate gradation shall be determined every 1800 metric tons [**2,000 tons**], or portion thereof (minimum of one per day), on samples taken at the same time as the required mixture sample for a given increment.

All gradations require a - 0.075 mm [**-#200**] wash.

(a) Virgin Aggregate Mixtures - Drum or Screenless Plants
Belt Samples or extracted production samples.
(b) All Other Mixtures:
1. Hot Bins - Drybatch (Optional)
2. Incinerator Oven Mn/DOT Laboratory Manual Method 1853 (Optional) except samples that contain over 50% class B. [(1)]
3. Extraction Mn/DOT Laboratory Manual Method 1851 or 1852 (Optional)

(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.

E7 **Coarse Aggregate Angularity.....ASTM D5821**

CAA test results shall meet the minimum percent fractured faces as shown in Table 2360.3-B2a. ASTM D-5821 shall be used to determine coarse aggregate angularity 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 requirements.
(2) If CAA crushing test results exceed 8 percent of the requirement, take one sample per day and perform one test per week.

CAA results must be reported on the test summary sheet. Mixture placed and represented by results below the minimum requirement, as shown in Table 2360.3-B2a, will be subject to reduced payment as outlined in Table 2360.4-L3. 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 specifications.

E8 Fine Aggregate Angularity ..... ASTM C1252 Method A

FAA test results shall meet the minimum criteria shown in Table 2360.3-B2a. ASTM C1252 Method A shall be used to determine fine aggregate angularity on the composite blend from aggregates used in production of HMA. 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 requirements.
(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 2360.3-B2a, will be subject to reduced payment as outlined in Table 2360.4-L3. Tonnage is 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 specifications.

E8a - 4.75 mm [-#4] Manufactured Crushed Fines..... (calculation) Mn/DOT Bituminous Manual

Under Marshall design, when the -4.75 mm [**-#4**] crushing is calculated, adjustments in target values from the composite blend must be made at the end of each days paving. If the target quantity (percent of -4.75 mm [**-#4**] to be crushed) changes due to mixture proportion or composite gradation change, a new target shall be established for the next days paving.

E9 Field Tensile Strength Ratio (TSR) ..... ASTM D4867 Mn/DOT Modified

At the discretion of the Materials Engineer, mixture will be sampled and tested to verify tensile strength ratio (TSR)[(1)]. If the Materials Engineer requires sampling and testing, both the Contractor and the Department will be required to test these samples within 72 hours after it is sampled. Sample size shall be 50 kg [**110 pound**] minimum and split in half to provide a sample for the Department and the Contractor. 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 24 hours of sampling, as specified by the Engineer. Mixture samples shall be taken from behind the paver unless the Engineer approves an alternate sampling location. Specimen size shall be 100 mm [**4 inch**] for Marshall mix design and 150 mm [**6 inch**] for gyratory design The Contractor may test the sample at a permanent lab site or a field lab site.

(1) When utilizing Option 2 mix design, it is recommended a sample be obtained within the first 4,500 metric tons [**5,000 tons**] of HMA produced or by the second day of production, whichever comes first, to verify tensile strength ratio (TSR).

Minimum acceptable TSR values for production are shown in Table 2360.4-E9. The Contractor shall stop production immediately if minimum TSR requirements are not met. The Contractor will not be allowed to resume production until anti-strip has been added to the asphalt binder. Determination of who is responsible for the cost of the anti-strip is based on Mn/DOT and Contractor TSR values as outlined in Tables 2360.4E9A, 2360.4E9B, and 2360.4E9C. When Mn/DOT is responsible for the cost of the anti-strip, payment will be made only for the cost of the anti-strip for mixtures placed on that project. Mn/DOT will not reimburse the Contractor for any delay costs associated with making changes related to this testing.

Table 2360.4-E9

Mixture Type- - Minimum TSR					
LV and MV		Gyratory Traffic Level 2-3		Traffic Level 4-5	
Contractor	Mn/DOT	Contractor	Mn/DOT	Contractor	Mn/DOT
70%	60%	75%	65%	80%	70%

Table 2360.4-E9A

LV and MV Mixtures		**Contractor TSR**	
		≥70	<70
Mn/DOT TSR	≥60	NA	Mn/DOT
	<60	Contractor	Contractor

Table 2360.4-E9B

Gyratory Level 2-3		**Contractor TSR**	
		≥75	<75
Mn/DOT TSR	≥65	NA	Mn/DOT
	<65	Contractor	Contractor

Table 2360.4-E9C

Gyratory Level 4-5		**Contractor TSR**	
		≥80	<80
Mn/DOT TSR	≥70	NA	Mn/DOT
	<70	Contractor	Contractor

Another sample shall be taken and tested within the first 450 metric tons [**500 tons**] after production resumes. If the re-test fails to meet the minimum specified value the Contractor shall stop production immediately. Production cannot resume until the Contractor has discussed, with the Engineer, a proposal for resolving the problem. The Contractor shall not operate below the specified minimum TSR on a continuing basis. A continuing basis shall be defined as 2 or more successive tests failing the TSR requirements.

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

1. A proportion change of more than 10 percent (from the currently produced mixture) for a single stockpile aggregate.
2. The discretion of the Engineer.

Dispute resolution procedures for TSR are on file in the Bituminous Office.

E10 Aggregate Specific Gravity (Gsb).....AASHTO T84 and T85, Mn/DOT modified

At the discretion of the District Materials Engineer, aggregate stockpiles will be sampled and tested to verify aggregate specific gravity. Representative stockpile samples shall be 40 kg [**90 pounds**] for each aggregate component. All samples shall be split in half to provide material for both the Department and the Contractor. 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 Plant Monitor immediately or delivered to the District Materials Engineer within 48 hours of sampling, as specified by the Engineer. Aggregate specific gravity results will be compared to the Contractor's values on the current Mix Design Report. If the results deviate beyond the tolerance specified in Table 2360.4-M, the District Materials Engineer will immediately contact the Contractor and issue a new Mix Design Report with the current specific gravity results. Any mixture placed following notification of new specific gravity values will be based upon Department results. The Contractor shall be notified immediately when new specific gravity values become available and what impact this will have on the calculated VMA. The dispute resolution procedure for aggregate specific gravity is on file in the Bituminous Office.

E11 Moisture Content .....Mn/DOT 5-693.950

Provide a mixture with 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 and testing shall be conducted by the Contractor on a daily basis unless exempted by 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, and use of covered stockpiles.

E12 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 1.0L [**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. The Contractor shall record sample information on Asphalt Sample Identification Card. Promptly submit the sample to the Department Materials Laboratory in Maplewood. Contact the Department Chemical Laboratory Director for disposition of failing asphalt binder samples.

F Documentation (Records)

The Contractor shall maintain documentation, including test summary sheets and control charts, on an ongoing basis. The Contractor shall also maintain a file of gyratory specimen heights for all gyratory compacted samples and test worksheets. 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 approved/supplied by the Department.

(2) Facsimile or when approved by the Engineer, electronically transmit (email) all production test results on test summary sheets to the District Materials Laboratory and to other sites as requested by the Engineer, by 11 AM of the day following production.

(2a) Include the following production test results and mixture information on the Department approved test summary sheet.

1. Percent passing on sieves listed in Table 2360.2-E
2. Coarse and fine aggregate crushing.
3. Maximum specific gravity ($G_{mm.}$).
4. Bulk specific gravity (G_{mb}).
5. Percent total asphalt binder content (P_b) and new added asphalt binder content.
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. Aggregate proportions in use at the time of sampling.
10. Tons where sampled.
11 Tons represented by a test and cumulative tons produced.
12. Fines to effective asphalt ratio (F/A_e).
13. Signature Line for Mn/DOT and Contractor Representative.
14. Mixture Moisture Content.
15. Mn/DOT verification sample test result.

(2b) Submit copies of all failing test results to the Engineer on a daily basis.

(3) Provide the Engineer with asphalt manifests or BOL's 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.

(6a) Provide a final hardcopy summary of all quality control test summary sheets and control charts at completion of bituminous operations on the Project to the Engineer. 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. The Contractor shall also submit a diskette of the quality control summary sheets, control charts and density worksheets to the Bituminous Engineer.

(7) Furnish an automated weigh scale and computer generated weigh ticket. The ticket shall indicate project number, mix designation (including binder grade), Mixture Design Report#, 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) Test summary sheets, charts, and records for a mixture produced at one plant site shall be continued from contract to contract. The Contractor shall begin new summary sheets and charts annually for winter carry-over projects. The Contractor shall begin new summary sheets and charts when an asphalt plant is re-setup in the same location after it has moved out.

G Documentation (Control Charts)

The following data shall be recorded on the standardized control charts, all control charts and summary sheets shall be computer generated using software approved by the Engineer. Software is available from the Mn/DOT Bituminous Office at www.mrr.dot.state.mn.us/pavement/bituminous/bituminous.asp.

(1) Blended aggregate gradation, include sieves shown in Table 2360.2-E for specified mixture.
(2) Percent asphalt binder content (P_b)
(3) Maximum specific gravity ($G_{mm.}$)
(4) Production air voids (V_a)
(5) VMA

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

H JMF Limits

The production air voids and VMA are based upon the minimum specified requirements as shown in Tables 2360.3-B2b and 2360.3B2c. Gradations and asphalt binder content limits are based upon the current Department reviewed Mixture Design Report. Gradation control sieves include each sieve shown in Table 2360.2-E. The mixture production targets are listed on the Mixture Design Report. JMF limits are the target plus or minus the limits shown in Table 2360.4-H. JMF limits are used as the criteria for acceptance of materials based on the moving average.

Table 2360.4-H
JMF Limits (N=4)

Item	JMF Limits
VMA, %	- 0.3
Production Air Voids, %	± 1.0
Asphalt Binder Content, %	- 0.4
Sieve - % Passing*	
25, 19, 12.5, 9.5, 4.75 mm [**1 inch, 3/4 inch, 1/2 inch, 3/8 inch, #4**]	± 7
2.36 mm [**#8**]	± 6
0.075 mm [**#200**]	± 2.0

*****JMF limits are not allowed outside the broadband requirements in Table 2360.2-E.

H1 Moving Average Calculation

A moving average is the average of the last four test results. The calculation of the moving average shall continue without interruption except under the following conditions:

1) The Contractor shall begin new summary sheets and charts annually for winter carry-over projects.
2) The Contractor shall begin new summary sheets and charts when an asphalt plant is re-setup in the same site after it has been moved out.
3) When there is a significant change of the materials in the currently produced JMF or when a new design JMF, significantly different from the currently produced JMF, is approved. The Engineer will determine whether a material change is significant.

I JMF Bands

JMF Bands are defined as the area between the target, as identified on the Mixture Design Report, and the JMF limits.

J JMF Adjustment

The Contractor shall begin mixture production with the materials (gradation, asphalt content, and aggregate proportions) closely conforming to the reviewed Mixture Design Report. Closely conforming shall be defined as aggregate proportions within 5 percent of the design proportions [(1)] and other mixture parameters within the JMF limits in Table 2360.4-H. This requirement may be waived if the Contractor provides the District Materials Laboratory with prior documented production data showing how production affects the mixture properties or if the Contractor provides the District Materials Laboratory with a written justification or explanation of material changes since the original mixture submittal.

(1) The Contractor shall begin mixture production using all aggregate proportions included on the Mixture Design Report unless the aggregate proportion is shown as 0 percent.

J1 JMF Request for Adjustment

If, during production, the Contractor determines from results of QC tests that adjustments to the mix design are necessary to achieve the specified properties, the following provisions shall apply. Unless otherwise authorized by the District Materials Engineer, no adjustments are allowed using aggregates or materials not part of the original mix design.

The Contractor shall make a request for a JMF adjustment to the Department Bituminous Engineer or District Materials Engineer. 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 Tables 2360.3-B2a and 2360.3-B2b, a revised Mixture Design Report 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. The adjusted JMF shall be within the mixture specification gradation design broadbands shown in Section 2360.2E. Should a redesign of the mixture become necessary, a new JMF shall be submitted. The JMF asphalt content may only be reduced if the production VMA meets or exceeds the minimum VMA requirement for the mixture being produced.

Adjustments will be made as a result of an interactive process between the Contractor, Engineer, and District Materials Engineer. Consecutive requests for JMF adjustments, without production data, are not allowed. The calculation of the moving average shall continue after the JMF has been approved.

J1a JMF Request for Adjustment for Proportion Change > 10%

If a JMF adjustment is requested for a proportion change exceeding 10% (from the currently produced mixture) for a single stockpile aggregate, supporting production test data from a minimum of four tests run at an accelerated testing rate of 1 test per 450 metric tons [**500 tons**] must be included with the request for adjustment. In addition to the requirements listed above, acceptable verification and approval of the requested JMF will be based on individual and moving average test results. Individual test results must be within twice the requested JMF limits for percent asphalt binder, production air voids, and VMA. Individual gradation must be within twice the requested JMF bands. The moving average values must be within the control limits of Table 2360.4-H. The calculation of the moving average shall continue after the change in proportions.

If the mixture meets the specified quality indicators, the request for JMF adjustment will be signed by the District Materials Laboratory and considered effective from the point the proportion change was made. Failure to meet the quality indicators will result in reduced payment or removal and replacement with acceptable material. Consecutive requests for JMF adjustments without production data are not allowed.

K Corrective Action -- Percent Asphalt Binder Content, VMA, and Gradation and Production Air Voids

When the moving average values trend toward the JMF limits, the Contractor shall take corrective action. The corrective action taken shall be documented on summary sheets and, if applicable, a request for JMF adjustment shall be submitted to the District Materials Engineer for review and approval. 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 JMF limits**.**

L Failing Materials

The determination of price adjustments for failing materials will be based on the criteria outlined in this Section. Material acceptance is based on individual and moving average test results. Isolated test results are used for acceptance of air voids at the start of mixture production. Generally, individual test results which are more than twice the JMF bands are considered failing. Moving average test results are considered failing when they exceed the JMF limits. The Contractor shall begin new summary sheets annually for winter carry-over projects.

If the moving average values exceed the JMF limits, the Contractor shall stop production and make adjustments. The Contractor shall restart production only after notifying the Engineer of the adjustments that have been made. Testing shall resume at the accelerated rates and for the tests listed in Table 2360.4-D for the next 1800 metric tons [**2,000 tons**] of mixture produced. The calculation of the moving average shall continue after the stop in production.

Mixture produced where the moving average of four exceeds the JMF limits shall be considered unsatisfactory and subject to requirements of Section 2360.4L4, L5, L6, and L7. Individual test failures are discussed in Section 2360.4L1, L2, and L3.

When the total production of a mixture type for the entire project requires less than four tests, acceptance of material will be consistent with the criteria outlined in Section 2360.4L1, L2, and L3.

When the Contractor's testing data fails to meet specified tolerances as listed in Table 2360.4-M, quality assurance/verification data shall be used in place of the Contractor's data to determine the appropriate payment factor.

L1 Isolated Failures at Mixture Start-Up – Production Air Voids

At the start-up of mixture production, before a moving average of four can be established the first three (3) isolated test results for production air voids will be used for acceptance. Isolated production air voids are calculated by using the maximum mixture specific gravity and the corresponding bulk specific gravity from that single test. After four (4) samples have been tested and a moving average of four can be established, acceptance will be based on individual and moving average production air voids.

If, at the start of production, any of the first three (3) isolated test results for production air voids exceeds twice the JMF bands from the target listed on the Mixture Design Report, the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the isolated test result is back within twice the JMF bands. When the failure occurs at the first test, after the start of production, the tonnage subjected to reduce payment shall be calculated as described above and shall include the tonnage from the start of production.

When isolated air voids are less than 1.0% or greater than 7.0% the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. To better define the area to be removed and replaced the Engineer may require the Contractor to test inplace mixture. This may include testing mixture placed prior to the failing test result. Reduced payment will be 50 percent of the Contract bid price.

L2 Individual Failure at Mixture Start-Up – VMA

At the start-up of mixture production, before a moving average of four can be established, the first three (3) individual test results for VMA will be used for acceptance. After 4 samples have been tested and a moving average of four can be established, acceptance will be based on individual and moving average VMA.

If, at the start of production, any of the first three (3) individual VMA test results exceeds twice the JMF bands from the target listed on the Mixture Design Report, the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the test results are back within twice the JMF limits. When the

failure occurs at the first test, after the start of production, the tonnage subjected to reduce payment shall be calculated as described above and shall include the tonnage from the start of production.

L3 Individual Failure - Gradation, Percent Asphalt Binder, Production Air Voids, and VMA

Table 2360.4-L3
Reduced Payment Schedule for Individual Test Results

Item	Pay Factor (1)
Gradation	95 %
Coarse and Fine Aggregate Crushing	90 %
VMA	90 %
Asphalt Binder Content	90 %
Production Air Voids (individual (2) and isolated (3))	80 %

(1) Lowest Pay Factor applies when there are multiple reductions on a single test.
(2) Individual air voids are calculated using the moving average maximum specific gravity and the bulk specific gravity from that single test.
(3) Isolated air voids are calculated from the maximum specific gravity and the bulk specific gravity from that single test. Isolated void test results are used for acceptance only for the first 3 tests after mixture production start-up.

If the individual gradation test exceeds twice the JMF bands from the target listed on the Mixture Design Report the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage represented by the individual test.

If the individual tests for percent asphalt binder content, production air voids, or VMA exceeds twice the JMF bands from the target listed on the Mix Design Report the material is considered unsatisfactory or unacceptable. Reduced payment as outlined in Table 2360.4-L3 shall apply to all tonnage placed from the sample point of the failing test until the sample point when the test result is back within twice the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall be calculated as described above and shall include the tonnage from the start of production that day.

When individual air voids are less than 1.0% or greater than 7.0% the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. To better define the area to be removed and replaced the Engineer may require the Contractor to test inplace mixture. This may include testing mixture placed prior to the failing test result. Reduced payment will be 50 percent of the Contract bid price.

L4 Moving Average Failure at Mixture Start-Up - Production Air Voids

When a moving average failure occurs within any of the first 3 moving average results after mixture start-up (tests 4, 5, 6), the mixture will be considered acceptable if the individual air void, corresponding to the moving average failure is within the JMF limits. If the individual air void is not within the JMF limit, the mixture will be considered unacceptable and is subject to reduced payment. The Engineer may waive the penalty if the isolated air void corresponding to the individual air void is within the JMF limit. Reduced payment will be 70 percent of the Contract bid price. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of the failing moving average result and corresponding individual air void beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit.

L5 Moving Average Failure at Mixture Start-Up - VMA

When a moving average failure occurs within any of the first 3 moving average results after mixture start-up (tests 4, 5, 6), the mixture will be considered acceptable if the individual VMA, corresponding to the moving average failure is within the JMF limits. If the individual VMA is not within the JMF limit, the mixture will be considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will

perform the work. Reduced payment will be 80 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of the failing moving average result and corresponding individual VMA beyond the JMF limit to the sampling point when the individual test result is back within the JMF limit.

L6 Moving Average Failure - Production Air Voids

A moving average production air void failure occurs when the individual production air void moving average of four exceeds the JMF limit. This mixture is considered unacceptable and is subject to reduced payment. Reduced payment will be 70 percent of the Contract bid price. Tonnage subjected to reduced payment shall be calculated as the tons placed from the sample point of all individual test results beyond the JMF limits which contributed to the moving average value that exceeded the JMF limit to the sampling point when the individual test result is back within the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

Table 2360.4-L6
Reduced Payment Schedule for Moving Average Test Results

Item	Pay Factor (1)
Gradation **(SEE FOOTNOTE #3 BELOW)**	80 %(3)
Coarse and Fine Aggregate Crushing	NA (individual failures only)
VMA(2)	80 %
Asphalt Binder Content	80 %
Production Air Voids(2)	70 %

(1) Lowest Pay Factor applies when there are multiple reductions on a single test.
(2) See criteria for mixture production start-up
(3) Excluding the 0.075 mm [#200] sieve, use 95% pay factor if failure is within aggregate gradation broadband, Table 2360.2-E.

L7 Moving Average Failure - Percent Asphalt Binder Content, VMA, and Gradation

For mixture properties including asphalt binder content, VMA, and gradation, where the moving average of four exceeds the JMF limits, the mixture is considered unacceptable and the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. If the mixture is to be removed and replaced, the Contractor at his expense will perform the work. Reduced payment will be 80 percent of the Contract bid price. Tonnage subjected to replacement or reduced payment shall be calculated as the tons placed from the sample point of all individual test results beyond the JMF limits which contributed to the moving average value that exceeded the JMF limit, to the sampling point when the individual test result is back within the JMF limits. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

L8 Coarse and Fine Aggregate Crushing Failure

If any test result for Coarse Aggregate Angularity, Fine Aggregate Angularity or -4.75mm [- **#4**] calculated crushing fail to meet minimum requirements in Table 2360.3-B2a, all material placed is subject to reduced payment as outlined in Table 2360.4-L3. 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 specifications. When the failure occurs at the first test after the start of daily production, tonnage subjected to reduced payment shall include the tonnage from the start of production that day.

M Quality Assurance

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 may obtain additional samples, at any time, to determine quality levels. These additional samples or verification samples are described in Section 2360.4N. For mixture, the Contractor shall test their portion immediately.

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 Quality assurance program.

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

Table 2360.4-M
Allowable Differences (Tolerances) Between Contractor and Mn/DOT Test Results*

Item	Allowable Difference
Mixture Bulk Specific Gravity (G_{mb})	0.030
Mixture Maximum Specific Gravity (G_{mm})	0.019
VMA (Calculated)	1.2
Fine Aggregate Angularity, uncompacted voids (U) %	1
Coarse Aggregate Angularity, % fractured faces (%P)	15
Aggregate Individual Bulk Specific Gravity (+4.75mm [**+ #4**])	0.040
Aggregate Individual Bulk Specific Gravity (-4.75mm [**- #4**])	0.040
Aggregate combined blend Specific Gravity (G_{sb})	0.020
Tensile Strength Ratio (TSR) %	See Table 2360.3-B2b
Asphalt Binder Content	
Meter Method, %	0.2
Spot Check Method, %	0.2
Chemical Extraction Methods, %	0.4
Incinerator Oven, %	0.3
Chemical vs. Meter, Spot Check, or Incinerator methods	0.4
Incinerator Oven vs. Spot Check	0.4
Gradation Sieve % passing	
25.0, 19.0, 12.5, 9.5 mm [**1 inch, 3/4 inch, 1/2 inch, 3/8 inch**]	6
4.75 mm [**#4**]	5
2.36 mm [**#8**]	4
0.075 mm [**#200**]	2.0

*Test tolerances listed are for single test comparisons.

N Verification Testing

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 and use this verification companion sample as part of the QC program. The verification companion sample will replace the next scheduled QC sample. It is recommended enough material be sampled to accommodate retesting should the samples fail to meet requirements as described below.

Verification testing shall be performed on at least one set of production tests Section 2360.4E, excluding sections E9, E10, E11, and E12, on a daily basis per mix type. The verification companion sample will be used to verify the requirements of Tables 2360.2-E, 2360.3-B2a, 2360.3-B2b, and 2360.3-B2c and will be compared to the Verification sample for compliance with allowable tolerances as specified in Table 2360.4-M. 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. For Coarse and Fine Aggregate crushing that

meets the requirements of Section 2360.4E7 and 2360.4E8 the one test per week shall be performed on a verification companion. 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 2360.4E1b or 2360.4E1c. Asphalt content from the verification test result must be used to determine VMA.

The Department's verification test results will be available to the Contractor within 2 working days from the time the sample is delivered to the District Laboratory for Gmm mixture max gravity, Gmb mixture bulk gravity, air voids (calculated), asphalt binder content, VMA (calculated). Gradation and crushing results will be provided to the Contractor within 3 Mn/DOT working days. Once the verification test results are available, they will be included on the test summary sheet. These results and those from the Contractor's verification companion will be compared for allowable tolerances as specified in Table 2360.4-M. If the tolerances are met, the verification process is complete.

If the tolerances between Department and Contractor are not met, retests of the material shall be conducted by the Department. If the retests fail to meet tolerances, the Department's verification test results will be substituted for the Contractor's results in the QC program and used for acceptance. Only those parameters out of tolerance will be substituted and, if applicable, volumetric properties will be recalculated [(1)].

When tolerances from the verification sample retests are not met, an investigation will begin immediately to determine the cause of the difference. Testing equipment, procedures, worksheets, gyratory specimen height sheets, and personnel will be reviewed to determine the source of the problem. The District Materials Engineer may also require a hot-cold comparison of mixture properties be performed. The procedure for hot-cold comparisons is as follows:

> 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 and third part will be allowed to cool to air temperature. The Contractor will retain the second part and the third part will be transported to the District Materials Laboratory. On the same day and at approximately the same time the Contractor and the District Materials Laboratory will heat their samples to compaction temperature and compact them. 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 or two gyratory specimens. This test may be repeated at the discretion of the Contractor or the District Materials Engineer.

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.

The Department will test the previously collected QA samples until they meet the tolerances or the remaining samples are all tested. Once these samples are tested, the department will test QA samples subsequent to the verification sample until tolerances are met. Acceptance will be based on QC data with substitution of Department test results for those parameters out of tolerance [(1)]. If reestablishment of test result tolerances is not achieved within 48 hours, the Contractor shall cease mixture production and placement until the problem is resolved.

(1) If, through analysis of data, it is determined there is a bias in the test results, the Engineer will determine which results are appropriate and shall govern. Methods to analyze data for determination of bias are on file in the Bituminous Office.

2360.5 CONSTRUCTION REQUIREMENTS

A General

The following construction requirements provide for the construction of all courses. When construction is under traffic, the requirements of Mn/DOT 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 roadbed conditions are unfavorable.

No asphalt pavement wearing course (final wearing course if multiple wearing courses) 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

(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 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 asphalt binder content of the mixture.

The working tank shall have a capacity between 3 800 L [**1,000 gallons**] and 7 600 L [**2,000 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 asphalt binder flow meter in addition to the asphalt binder pump. The flow meter shall be connected to the asphalt binder supply to measure and display only the asphalt binder 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 asphalt binder pump. In addition, the system shall display in liters [**gallons**] or to the nearest 0.001 metric tons [**0.001 tons**], the accumulated asphalt binder 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

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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, if the paving width is greater than the basic screed, auger and mainframe extensions, which meet manufacture's recommendations for the paving width, are required unless otherwise directed by the Engineer. Strike-off only extension assemblies are not allowed for mainline wearing course paving, unless directed by the Engineer.

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.

Automatic screed control by means of an 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 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, when approved by the Engineer, 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. When approved by the Engineer, mixtures may be spread by a motor grader in areas that are inaccessible to a paver such as on driveway entrances, irregular areas, short isolated areas or when 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 2360.5B. 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 airflow 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 [**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 wheelbase 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 2357. Emulsified asphalt tack coats shall be allowed to break, as indicated by a color change from brown to black, before a subsequent lift is placed.

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 density requirements as outlined in Section 2360.6 Pavement Density.

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

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 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. 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.

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 Small Quantity HMA Paving

Unless otherwise indicated in the Special Provisions, the following provision for a small quantity of asphalt mixture shall apply.

A Mixture Design Report is not required for planned project quantities less than 191,200 m^2 mm [**9,000 square yard inches [4,500 square yards per 2 inch thickness, etc**]) or 450 metric tons [**500 tons**]. However, the Contractor shall verify in writing the asphalt mixture delivered to the project meets the requirements of Table 2360.3-B2a and Table 2360.3B2b. The Department will obtain samples, as determined by the Engineer, to verify mixture requirements. These results will be used for material acceptance. Acceptance of material will be in accordance with the criteria outlined in Section 2360.4L1, L2, L3, and L8.

2360.6 PAVEMENT DENSITY

A General

All pavements will be compacted in accordance with the Maximum Density Method unless otherwise specified in the Contract special provisions or as noted in Section 2360.6C.

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 2360.6-B2, for the applicable mixture and course.

B1 Maximum Density Determination

The Density requirements listed in Table 2360.6B2 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 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.

B1a 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 as described above). Determination of the bulk specific gravity of the cores shall be in accordance with AASHTO T-166, Mn/DOT modified. For coarse graded mixtures the Engineer may require determination of bulk specific gravity of the cores be in accordance with ASTM D6752 Mn/DOT modified (Corelok). Both the Contractor and Mn/DOT shall use the same test method to determine bulk specific gravity. The determination of coarse and fine graded mixtures will be based on the percentage of material passing the 2.365 mm sieve [**#8**] as defined in Table 2360.3-B2c.

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 continual basis shall be defined as all lots in a day's 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 specified minimum required density.

B2 Required Density

Minimum density requirements for both gyratory (SP) and Marshall designed mixtures are listed in Table 2360.6-B2.

Unless otherwise indicated in the Plans or Special Provisions, shoulders wider than 1.8 meters [**6 feet**] paved shall be compacted by the Maximum Density Method. When shoulders are required to be compacted by the Maximum Density Method and are paved in a separate operation or have a different required minimum density than the driving lane, the lot tonnage placed on the shoulder shall be delineated in separate lots from the driving lanes for the day paving was conducted.

Unless otherwise indicated in the Plans or Special Provisions a narrow shoulder, 1.8 meter [**6 feet**] or less wide, that is paved in the same pass as a driving lane or that is paved separately will be compacted by the Ordinary Compaction Method. Mixture compacted under Ordinary Compaction is excluded from lot density requirements and that tonnage is also excluded from incentive/disincentive payment.

If the Plans or Special Provisions indicate a narrow shoulder is to be compacted by the Maximum Density Method, the minimum required density is listed in Table 2360.6-B2. If the minimum required density of the shoulder is different than the driving lane, the tonnage placed on the shoulder shall be delineated in separate lots from the driving lane.

Echelon paving (two pavers operating next to each other in adjacent lanes) shall be considered separate operations.

Table 2360.6-B2
Required Minimum Lot Density

	SP Wear and All MV and LV Mixtures [(1)(2)]	**SP Nonwear** [(1)(2)]	**SP Shoulders** [(1)(2)]	
			Designed at 3% voids	Designed at 4% voids
% Gmm	92.0	93.0	93.0	92.0

1) Minimum reduced by one percent on the first lift constructed over PCC pavements.
2) Minimum reduced by one percent for the first lift constructed on aggregate base (mainline and shoulder), reclaimed or cold inplace 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 (roadway includes shoulders).

B2a Lots & Core Locations

Table 2360.6-B2a
Lot Determination

Daily Production		Lots
Metric (ton)	[**English (Ton)**]	
270* – 545	[**300* – 600**]	1
546 – 910	[**601 – 1,000**]	2
911 – 1,455	[**1,001 – 1,600**]	3
1,456 – 3,275	[**1,601 – 3,600**]	4
3,276 – 4,545	[**3,601 – 5,000**]	5
4,546 +	[**5,001 +**]	6

*When mix production is less than 270 metric tons [**300 tons**], establish 1st lot when accumulative tonnage exceeds 270 metric tons [**300 tons**].

Divide the days production into equal lots as shown in Table 2360.6-B2a. The Engineer may require additional density lots be established to isolate areas affected by equipment malfunction/breakdown, heavy

rain, or other factors that may affect the normal compaction operations. 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 within 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 Engineer using statistically derived stratified random number tables or other approved methods of random number generation. These will also be used for partial lots. Both transverse and longitudinal joints are subject to maximum density requirements. If the random core location falls on an unsupported joint, at the time of compaction, (the edge of the mat being placed does not butt up against another mat, pavement surface, etc.) cut the core with the outer edge of the core barrel 0.3 meters [**1 foot**] away (laterally) from the edge of the top of the mat (joint). If the random core location falls on a confined joint (edge of the mat being placed butts up against another mat, pavement surface, curb and gutter, or fixed face), cut with the outer edge of the core barrel 150 mm ± 12.5 mm [**6 inches ± 0.5 inch**] from the edge of the top of the mat (ex. center of 100 mm [**4 inch**] core barrel 200 mm ± 12.5 mm [**8 ± 0.5 inches**] from the edge of the top of the mat). Cores will not be taken within 300 mm [**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.

B3 Core Testing

Cores will be taken and tested by the Contractor. Core locations will be determined and marked by the Engineer. The Contractor shall schedule the approximate time of testing during normal project work hours so that the Engineer may observe and record the saturated surface dry and immersed weight of the cores.

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 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.

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 2360.7A

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, through analysis of data, it is determined there is a bias in the test results, the Engineer will determine which results are appropriate and shall govern.

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 Maximum Density Acceptance and Payment Schedule

The density of compacted mixture shall be accepted by pavement cores on a lot basis.

The Contractor's cores will be used for acceptance if the determined bulk specific gravity G_{mb} from AASHTO T-166, Mn/DOT modified or ASTM D6752 Mn/DOT modified (Corelok) is within $\pm$ 0.030 of the state companion G_{mb} value. Payment for lot densities of compacted mixture shall be determined from Table 2360.6-B4 or 2360.6-B4A. Incentive and disincentive payments are for both wearing and non-wearing courses.

When the density requirement has been reduced by one percent, per Table 2360.6-B2, footnote 1 & 2, payment adjustments for lot densities will be made as specified in Table 2360.6-B4A. Incentive payments are excluded when the minimum density has been reduced. However, at the Contractors request and with approval of the Engineer, the reduced density requirement may be waived and density evaluated under Table 2360.6-B4, including incentives, for first lift constructed on aggregate base, reclaimed or cold inplace 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 (reduced density shall not be waived for the first lift constructed on PCC pavements). The request and approval shall be made after the first days paving and before the third days paving begins. Once the request has been approved, evaluation of density will be in accordance with Table 2360.6-B2 (excluding footnote 2) and Table 2360.6-B4, and will remain in effect for the duration of mixture placement on that lift. The Contractor will also be responsible for compliance with any construction requirements on subsequent lifts.

Table 2360.6-B4
Payment Schedule for Maximum Density

Percent of Max Specific Gravity [2] SP Wear All MV & LV , SP Shld (4% Void)	Percent of Max Specific Gravity [2] SP Non-Wear SP Shoulders (3% Void)	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 90.0	[4]

Table 2360.6-B4A [1]
1% Reduced Table

Percent of Max Specific Gravity [2] SP Wear All MV & LV , SP Shld (4% Void)	Percent of Max Specific Gravity [2] SP Non-Wear SP Shoulders (3% Void)	Percent Payment
91.0 and above	92.0 and above	100
90.0 - 90.9	91.0- 91.9	98
89.7 - 89.9	90.5 - 90.9	95
89.4 - 89.6	90.0 - 90.4	91
89.2 - 89.3	89.5 –89.9	85
89.0 - 89.1	89.0 - 89.4	70
Less than 89.0 [4]	Less than 89.0	[4]

(1) Minimum reduced by one percent for the first lift constructed on aggregate base (mainline and shoulder), reclaimed or cold inplace 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 (roadway includes shoulders). Minimum reduced by one percent on the first lift constructed on PCC pavements (reduced density cannot be waived).

(2) In calculating the percent of maximum specific gravity, report to the nearest tenth.

(3) The payment in this portion of the specification shall apply only if the day's weighted average individual production air voids are within - 0.5 percent of the target air void value. The weighted

average air voids shall be based on all the mixture production tests (2360.4e) for the corresponding day and shall be weighted by the tons the corresponding test represents.

(4) The HMA material represented by the lot shall be paid at a 70% pay factor, unless a single core density is less than 87.0% of the maximum specific gravity (Gmm). If a single core density is less than 87.0% of Gmm, the Engineer will decide whether the mixture is subject to removal and replacement or reduced payment. Reduced payment will be 50 percent of the Contract bid price. If the mixture is to be removed and replaced, the Contractor at his expense will remove and replace with mixture that meets the density requirement. The limits of the area to be removed and replaced will be determined by additional core samples. These additional core samples shall be taken at the same offset from centerline as the original core; unless the original low density core was taken within 0.45 m [**1.5 feet**] of an edge of the paver pass. In that case, the additional cores shall be taken 0.45 m [**1.5 feet**] from the edge of the paver pass. The densities shall be determined at 15 m [**50 foot**] intervals, both ahead and back of the point of unacceptable core density (less than 87.0% of Gmm), until a point of acceptable core density (87.0% of Gmm or greater) is found. If the incremental core density testing extends into a previously accepted lot, removal of the unacceptable material will be required; however, the results of these tests shall not be used to recalculate the previously accepted lot density. All costs incurred from additional coring and testing, resulting from unacceptable core density, will be paid by the Contractor. The unacceptable pavement area is to be computed as the product of the longitudinal limits so determined by the 15 m [**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.

After the unacceptable material (core density less than 87.0% of Gmm) has been removed and replaced, the density of the replacement material will be determined by the average of two cores. Payment for the replacement material will be in accordance with Tables 2360.6-B4 or 2360.6-B4A, whichever applies. There will be no payment for the material removed. The remainder of the original lot shall have a 70% pay factor.

C Ordinary Compaction Method

Ordinary compaction shall be used for layers identified in the typical sections with a minimum planned thickness of less than 40 mm [**1 1/2 inches**], thin lift leveling, wedging layers, patching layers, driveways, areas which cannot be compacted with standard highway construction equipment. Unless otherwise indicated in the Plans or Special Provisions recreational trails shall also be compacted by ordinary compaction. The ordinary compaction method shall not be used on mainline, ramp, or loop paving, unless otherwise designated in the plans or special provisions. When density is evaluated by the ordinary compaction method 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 m^2 [**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 and a growth curve shall be developed to determine the optimum rolling pattern. 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 or suitable approved alternate after each roller pass. 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 HMA mixture being placed.

The nuclear testing device 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 HMA 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 tons**] 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 has 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 [**3,085 lbf 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 wheel load force shall be a minimum of 13 kN [**3,000 pounds**] per wheel for LV and MV mixtures and SP Level 2-3 mixtures and 22 kN [**5,000 pounds**] per wheel for SP Level 4-6 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.

C3a Vibratory Pneumatic-Tired Rollers

Vibratory pneumatic-tired 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. The compacting width shall be 1.5 m [**5 feet**] or more. The tire arrangement shall be such that full compaction will be obtained over the full width with each pass of the roller.

C4 Trench Rollers

Trench rollers shall be self propelled and have a mass of not less than 4 400 kg per meter [**2,960 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 asphalt mixture shall be in accordance with the temperature requirements of Table 2360.6-C5. Unless directed by the Engineer in writing, no paving is allowed under the Ordinary Compaction Method when the air temperature is below 0°C [**32°F**].

Table 2360.6-C5
Mixture Temperature Control

Air Temperature	**Compacted Mat Thickness, mm (A)**			
°C [**°F**]	25 mm [**1 inch**]	40 mm [**1-1/2 inch**]	50 mm [**2 inch**]	≥75 mm [**3 inch**]
+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.

2360.7 THICKNESS AND SURFACE SMOOTHNESS REQUIREMENTS

A Thickness

After compaction the thickness of each lift 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 lift placed. This thickness requirement will not apply to a leveling lift whether or not automatic grade controls are

required. The Engineer may require removal and replacement, at the Contractor's expense, of any part of any lift that is constructed to less than the minimum required thickness.

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 day per lift will be used to determine daily compliance with thickness specifications.

On that portion of any lift constructed to more than the maximum permissible thickness, the materials used in the excess mixture above that required to construct that portion of the lift to the Plan thickness plus 6 mm [**1/4 inch**] may be excluded from the pay quantities and at the discretion of the Engineer and at the Contractor's expense may be required to be removed and replaced.

B Surface Requirements

After compaction, the finished surface of each lift shall be reasonably free of segregated, 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 lift 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 lift placed other than leveling when automatic controls are used.

(2) The surface of the final two lifts placed shall show no variation greater than 6 mm [**1/4 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 bypasses 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) After final compaction, all final lift asphalt wearing surfaces adjacent to concrete pavements shall be slightly higher (but not to exceed 6 mm [**1/4 inch**] than the concrete surface.

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.

(4) Transverse joints (construction joints), at the beginning and end of a project, at paving exceptions, or caused by suspension of daily paving operations, shall show no variation greater than 6 mm [**1/4 inch**] from the edge of a 3 m [**10 foot**] straightedge centered longitudinally across the transverse joint. The Engineer may require correction by diamond grinding when material is placed outside the above-described limitations.

(5) The transverse slope of the surface of each lift, exclusive of the shoulder wearing lift, shall not vary from the slope shown in the Plans by more than 0.4 percent.

(6) The distance between the edge of each lift 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 lift 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.

(7) The finished surface of each lift shall be reasonably free of segregated and open and torn sections and deleterious materials.

Any material placed outside the above described limitations shall be removed and replaced after being cut or sawed at no expense to the Department or with the approval of the Engineer, allowed to remain inplace at a reduced cost calculated at $12 per square meter [**$10 per square yard**]. Any single occurrence of material outside the limitations described above shall be considered to have a minimum dimension of one square meter [one square yard] in any dimension.

C Pavement Smoothness Specification – IRI (International Roughness Index)

C1 General

Pavement smoothness will be evaluated on the final mainline pavement surface using an Inertial Profiler (IP) and the International Roughness Index (IRI). Unless otherwise authorized by the Engineer, all smoothness testing shall be performed in the presence of the Engineer. The Engineer and the Contractor shall mutually agree upon scheduling of smoothness testing so that testing can be observed. Any testing performed without the Engineer's presence, unless otherwise authorized, may be ordered retested at the Contractor's expense. The following Table 2360.7-A (IRI) shows pavement surfaces that are excluded from smoothness testing but subject to 2360.7B surface requirements.

Table 2360.7 – A (IRI)
Testing Exclusions

7.62 m **[25 foot]** feet either side of obstructions such as manholes, water supply castings, etc.*
Ramps, Loops, Climbing lanes
Side Streets, Side Connections
Turn Lanes, Storage Lanes, Crossovers, Bypass Lanes
Shoulders
Intersections constructed under traffic – Begin and end the exclusion 30.5m [**100 feet**] from the intersection radius
Sections less than 7.62 m **[25 foot]** in length
Acceleration, Deceleration Lanes
Projects less than 300m [**1000 feet**] in length
Mainline paving where the normally posted regulatory speed is less than or equal to 70 km/hr [**45 miles per hour**]
Begin the exclusion at the sign
Single lift overlays over concrete

*Mainline shall be included in profiling if obstructions are located in auxiliary or parking lanes

C1A Smoothness Requirements

Pavement smoothness requirements will be evaluated by the International Roughness Index (IRI) Equation A, Equation B, or Equation C. The pavement smoothness Equation will be identified in the Special Provisions of the proposal. Location of bumps and/or dips and magnitude will be based on California Test Method 526.

C2 Measurement

Smoothness will be measured with an IP, which produces both an IRI value and a profilogram (profile trace of the surface tested). The IP shall conform to the Class 1 requirements of ASTM E950-94 and must be certified according to the most recent procedure on file in the Bituminous Office. For pavement evaluation, one pass will be made in the right wheel path of each traffic lane. The IP shall be run in the direction the traffic will be moving. Each lane will be tested and evaluated separately. The Engineer will determine the length in kilometers [**miles**] for each mainline traffic lane. The IP shall be operated at the optimum speed as defined by the manufacturer.

C3 Smoothness testing

The Contractor shall furnish a properly calibrated, documented, and MnDOT certified IP. The IP shall be equipped with automatic data reduction capabilities. Computer programs used to calculate the IRI statistic from a longitudinal roadway profile shall follow the procedure developed by the World Bank for a quarter-car simulation as described in NCHRP report 228.

Mn/DOT certification documentation shall be provided to the Engineer on the first day the IP is used on the project. IP settings are on file in the Bituminous Office. The Contractor shall furnish a competent operator, trained in the operation of the IP and evaluation of both California Test Method 526 and the International Roughness Index.

The Contractor shall remove all objects and foreign material on the pavement surface prior to surface evaluation by power brooming.

The pavement surface will be divided into sections which represent continuous placement. A section will terminate 7.62 m **[25 foot]** before a bridge approach panel, bridge surface, manhole or similar interruption. In the final pavement evaluation, 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 mi]**. A segment will be in one traffic lane only.

An IRI value shall be computed for each segment of 7.62 m **[25 foot]**or more. The IRI value will include the 7.62 m **[25 foot]** at the ends of the section only when the Contractor is responsible for the adjoining surface.

End of run areas not included in the IRI value and any sections of pavement less than 7.62 m **[25 foot]** in length shall be checked longitudinally with a 3.028 m **[10 ft]** straight edge and the surface shall not deviate from a straight line by more than 6 mm in 3.028 m **[1/4 inch in 10 ft]**. Transverse joints shall be evaluated by centering the straightedge longitudinally across the transverse joint.

The Contractor shall submit the graphical trace, a summary of the bump(s)/dip(s) locations, the magnitude of the bump(s)/dip(s) and each segment IRI value on the same day as the profiling was conducted.

The Contractor shall submit a final spreadsheet summary of the smoothness data to the Engineer within five calendar days after all mainline pavement placement. The summary shall be signed by the Contractor. The spreadsheet summary shall be in tabular form, with each 0.1 km **[0.1 mile]** segment occupying a row. Each row shall include the beginning and ending station for the segment, the length of the segment, the final IRI value for the segment~~,~~ the IRI based incentive/disincentive in dollars for the segment, and the deductions for bump(s)/dip(s) in dollars for the segment. Each continuous run will occupy a separate table and each table will have a header that includes the following: the project number, the roadway number or designation, a lane designation, the mix type of the final lift, the PG binder of the final lift, the date of the final smoothness runs, and the beginning and ending station of the continuous run. The following information shall be included at the bottom of each summary: a subtotal for the IRI based incentive/disincentive, a subtotal for the bump deductions, and a total for incentive/disincentive for both IRI values and bumps. Software to summarize the data is available from the Mn/DOT Bituminous Office at www.mrr.dot.state.mn.us/pavement/bituminous/bituminous.asp.

The Contractor will be responsible for all traffic control associated with the smoothness testing and any corrective action (when applicable) that is required of the final pavement surface.

C3A Retesting

The Engineer may require any portion or the total project to be retested if the results are questioned. This includes both IRI values and bump/dip locations. The Engineer will decide whether Mn/DOT, an independent testing firm (ITF), or the Contractor will retest the roadway surface.

If the retested IRI values differ by more than 10% from the original IRI values, the retested values will be used as the basis for acceptance and any incentive/disincentive payments. In addition, bump/dip locations as shown by the retest will replace the original results.

If the Engineer directs the Contractor or an independent testing firm to perform retesting and the original results are found to be accurate, the Department will pay the Contractor or the independent testing firm $62.14 per lane km [$100 per lane mile] that is retested, with a minimum charge of $500.00. The Contractor will be responsible for any costs associated with retesting if the original values differ by more than 10% from the retested values.

C4 IRI Values

The IP shall be equipped with automatic data reduction capabilities for determining the IRI values. An IRI value shall be calculated for each segment of the final pavement surface. Segments greater than or equal to 7.62 m [25 feet] and less than 161m [528 feet] shall be evaluated as a separate segment. The IRI values shall be determined by following NCHRP report 228. The IRI values shall be reported in units of m per km **[inches per mile]**. Both m per km and inches per mile shall be reported with two digits right of the decimal. Follow Mn/DOT rounding procedures per the Bituminous Manual section 5-693.730.

C4a Bumps and Dips – IRI Equation A and IRI Equation B

Bump/dip location will be determined in accordance with California Method 526. Bumps and dips equal to or exceeding 10.2 mm in a 7.62 m **[0.4 inch in a 25 ft]** 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.

The Contractor shall correct, by diamond grinding, all areas represented by bumps or dips of 10.2 mm **[0.4 inch]** or more as measured by California Test Method 526. However, the Engineer may allow bumps or dips of 10.2 mm to 15.2 mm **[0.4 inches to 0.6 inches]** in a 7.62 m **[25 foot]** span to be left uncorrected, and in such case, the contractor will be assessed a price deduct as specified in section C6 (“Payment”) of this special provision.

Corrected dips or bumps will be considered satisfactory when the profilogram shows the deviations are less than 10.2 mm in a 7.62 m **[0.4 inch in a 25 foot]** span.

C4b Bumps and Dips – IRI Equation C

Bump/dip location will be determined in accordance with California Method 526. Bumps and dips equal to or exceeding 12.7 mm in a 7.62 m **[0.5 inch in a 25 ft]** 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.

The Contractor shall correct, by diamond grinding, all areas represented by bumps or dips of 12.7 mm **[0.5 inch]** or more as measured by California Test Method 526. However, the Engineer may allow bumps or dips of 12.7 mm to 17.8 mm **[0.5 inches to 0.7 inches]** in a 7.62 m **[25 foot]** span to be left uncorrected, and in such case, the contractor will be assessed a price deduct as specified in section C6 (“Payment”) of this special provision.

Corrected dips or bumps will be considered satisfactory when the profilogram shows the deviations are less than 12.7 mm in a 7.62 m **[0.5 inch in a 25 foot]** span.

C5 Surface Correction

Unless otherwise approved by the Engineer, corrective work shall be by diamond grinding. Other methods may include; overlaying the area, or replacing the area by milling and inlaying. The Engineer shall approve of the Contractor's method of correcting segment(s) prior to the Contractor starting corrective work. Any corrective actions by milling and inlay or overlay shall meet the specifications for ride quality over the entire length of the correction, including the first and last 7.62 m **[25 foot]**. Bumps or dips in excess of 10.2 mm [**0.4 inches]** where evaluation is by Equation A or B or bumps or dips in excess of 12.7 mm **[0.5 inch]** where evaluation is by Equation C that are located at transverse joints at areas of corrective actions utilizing overlay or milling and inlay, shall be removed by diamond grinding. The Contractor shall notify the Engineer prior to commencement of the corrective action. If the surface is corrected by overlay, inlay or replacement, the surface correction shall begin and end with a transverse saw cut. Surface corrections shall be made prior to placing permanent pavement markings. In the event that permanent pavement marking are damaged or destroyed during surface correction activities, they will be replaced at no cost to the Agency.

When pavement smoothness evaluation by Equation A is specified the Engineer may require that the Contractor, at no expense to the Department, correct segments with an IRI greater than 1.03 m per km **[65 inches/mile] or the** Engineer may assess a $560 per 0.1 km **[$900 per 0.1 mile]** penalty in lieu of requiring corrective work.

When pavement smoothness evaluation by Equation B is specified the Engineer may require that the Contractor, at no expense to the Department, correct segments with an IRI greater than 1.18 m per km **[75 inches/mile] or the** Engineer may assess a $420 per 0.1 km **[$675 per 0.1 mile]** penalty in lieu of requiring corrective work.

When pavement smoothness evaluation by Equation C is specified the Engineer may require that the Contractor, at no expense to the Department, correct segments with an IRI greater than 1.34 m per km **[85 inches/mile] or the** Engineer may assess a $280 per 0.1 km **[$450 per 0.1 mile]** penalty in lieu of requiring corrective work.

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 subject to the approval of the Engineer. After all required corrective work is completed a final segment(s) IRI value and bump/dip tabulation shall be determined and submitted to the Engineer. Corrective work and re-evaluation shall be at the Contractor's expense.

Segments requiring grinding will be re-profiled within two working days of completion of grinding. Individual bumps/dips and segments requiring grinding shall be completed with 15 working days of notification.

C6 Payment

The cost of traffic control for certified smoothness testing and/or any corrective work is 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 IRI value. The total ride incentive shall not exceed 10% of the total mix price for pavement smoothness evaluated under IRI Equation A, 5% of the total mix price for pavement smoothness evaluated under Equation B, or 5% of the total mix price for pavement smoothness evaluated under Equation C. Total mix shall be defined as **all** mixture placed on the project. Only those segments which have had no corrective work or work to improve the ride are eligible for IRI incentive payment. Incentive payment for IRI will be based on the roadway segment before corrective work is performed. Grinding of the segment into incentive payment or grinding of the segment in order to obtain a higher incentive payment is not allowed. IRI incentive payment is independent of pay adjustment for bumps and dips.

The Contractor will not receive a net incentive payment for ride if more than 25% of all density lots (excluding longitudinal joint density) for the project fail to meet minimum density requirements.

For pavement smoothness evaluated under Equation A uncorrected bumps or dips greater than or equal to 10.2 mm **[0.4 inches]** in a 7.62 m **[25 foot]** span will be assessed a price deduction of $900 per event.

For pavement smoothness evaluated under Equation B uncorrected bumps or dips greater than or equal to 10.2 mm **[0.4 inches]** in a 7.62 m **[25 foot]** span will be assessed a price deduction of $675 per event.

For pavement smoothness evaluated under Equation C uncorrected deviations (bumps or dips) greater than or equal to 12.7 mm **[0.5 inches]** in a 7.62 m **[25 foot]** span will be assessed a price deduction of $450 per event.

Combinations of bumps and dips which arise from the same single bump or dip are considered to be one event, and shall be counted only once for the purposes of calculating price deductions. Typically, bump-dip-bump combinations, or dip-bump-dip combinations, that are confined to a 30 feet longitudinal segment are considered to be one event.

Bumps or dips resulting from a construction joint will be assessed a $900 penalty, regardless of the IRI Equation used for evaluation or pavement smoothness.

Incentive/disincentive payments will be based on the IRI determined for each segment and will be based on the following equations and criteria.

C6a IRI Equation A*

IRI m/km **[inches/mile]**	Incentive/Disincentive $/0.1km **[$/0.1mile]**
< 0.47 m/km **[< 30 inches/mile]**	$249 **[$400]**
0.47 m/km to 1.03 m/km [**30 inches/mile to 65 inches/mile]**	$523 – (IRI x 584) **[$850 – (IRI x 15)]**
1.03 m/km **[> 65 inches/mile]**	-$560 **[-$900]**

* Typically, 3-lift minimum construction

C6b IRI Equation B*

IRI m/km **[inches/mile]**	Incentive/Disincentive $/0.1km **[$/0.1mile]**
< 0.52 m/km **[< 33 inches/mile]**	$168 **[$270]**
0.52 m/km to 1.18 m/km [**33 inches/mile to 75 inches/mile]**	$373 – (IRI x 395) **[$600 – (IRI x 10)]**
1.18 m/km **[> 75 inches/mile]**	-$420 **[-$675]**

* Typically, 2-lift construction

C6c IRI Equation C*

IRI m/km **[inches/mile]**	Incentive/Disincentive $/0.1km **[$/0.1mile]**
< 0.57 m/km **[< 36 inches/mile]**	$112 **[$180]**
0.57 m/km to 1.34 m/km [**36 inches/mile to 85 inches/mile]**	$258 – (IRI x 257) **[$414 – (IRI x 6.5)]**
1.34 m/km **[> 85 inches/mile]**	-$280 **[-$450]**

* Typically, single lift construction

2360.8 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 (mm [inch]) and for Mixtures Measured by the [Square Yard inch]

Asphalt mixture of each type and for each specific lift will be measured separately by area and by thickness on the basis of actual final dimensions placed. The constructed thickness shall meet tolerances set forth in Sections 2360.7A.