

REVISION OF SECTIONS 401, 403 AND 702 RUBBERIZED ASPHALT PAVEMENT

Sections 401, 403, and 702 of the Standard Specifications are hereby revised for this project as follows:

Subsection 401.01 shall include the following:

This work includes furnishing, placing and compacting one or more courses of rubberized bituminous mixture on a prepared foundation in accordance with these specifications and the specific requirements, and in conformity with the lines, grades, thicknesses, and typical cross sections as established by the Engineer.

Subsection 401.02 (a) shall include the following:

Laboratory mixing and compaction of terminal blended (TB) rubberized asphalt cement PG 64-28TB and wet process (WP) rubberized asphalt cement PG 64-28WP shall be in conformance with the requirements of Colorado Procedure CP-L 5117 using the mixing and compaction temperature for asphalt grade PG 64-28.

Subsection 401.06 shall include the following:

Asphalt-rubber binder PG 64-28TB and PG 64-28WP shall consist of a mixture of paving asphalt, asphalt modifier such as styrene-butadiene-styrene (if needed), and crumb rubber modifier (CRM). At least 2 weeks before construction is scheduled to begin, the Contractor shall furnish the Engineer, for approval, a binder formulation and four (4) one-liter cans filled with the asphalt-rubber binder proposed for use on the project. The asphalt cement shall meet the applicable requirements of Table 702-1A.

Subsection 401.07 shall include the following:

All gradings and all layer thicknesses of HMA using PG 64-28TB and PG 64-28WP shall be placed only when the surface and air temperatures are 65°F or above.

Subsection 401.08 shall include the following:

The method and equipment for combining paving asphalt, asphalt modifier, and CRM for PG 64-28WP shall be so designed and accessible that the Engineer can readily determine the percentages by mass for each material being incorporated into the mixture.

The Contractor shall use, but is not limited to, the following for the wet process production of PG 64-28WP:

1. Asphalt heating tanks equipped to heat and maintain the blended paving asphalt and asphalt modifier mixture at the necessary temperature before blending with the CRM. This unit shall be equipped with a thermostatic heat control device and a temperature reading and recording device that shall be accurate to within $\pm 35^{\circ}\text{F}$.
2. A mechanical mixer for the complete, homogeneous blending of paving asphalt, asphalt modifier, and CRM. The blending system shall be capable of varying the rate of delivery of paving asphalt and asphalt modifier proportionate with the delivery rate of CRM. During the proportioning and blending of the liquid ingredients, the temperature of paving asphalt and the asphalt modifier shall not vary more than $\pm 60^{\circ}\text{F}$. The mixing system for paving asphalt, asphalt modifier, and CRM feeds shall be equipped with devices by which the rate of feed can be determined during the proportioning operation.

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Meters used for proportioning individual ingredients shall be equipped with rate-of-flow indicators to show the rates of delivery and resettable totalizers so that the total amounts of liquid ingredients introduced into the mixture can be determined. The liquid and dry ingredients shall be fed directly into the mixer at a uniform and controlled rate. The rate of feed to the mixer shall not exceed that which will permit complete mixing of the materials. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected by a reduction in the volume of material or by other adjustments. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly blended asphalt-rubber binder of unchanging appearance and consistency is produced.

The Contractor shall provide a safe sampling device capable of delivering a representative sample of the completed asphalt-rubber binder of sufficient size to permit the required tests.

3. An asphalt-rubber binder storage tank equipped with a heating system furnished with a temperature reading device to maintain the proper temperature of the asphalt-rubber binder and an internal mixing unit capable of maintaining a homogeneous mixture of paving asphalt, asphalt modifier, and CRM. The equipment shall be approved by the Engineer prior to use.
4. A manufacturer's representative shall be present during production.
5. The Contractor shall provide a hand-held Rion (formerly Haake) Model VT-04 viscotester with Rotor 1, 24 mm in depth and 53 mm in height, or equivalent, at the production site during combining of asphalt-rubber binder materials.

Subsection 401.13 shall include the following:

The PG 64-28WP shall be blended paving asphalt and the CRM combined and mixed together at the production site in a blender unit to produce a homogeneous mixture. The temperature of the blended paving asphalt mixture shall be between 375°F and 440°F when the CRM is added. The CRM shall be combined at the production site and shall contain 97 to 100 percent scrap tire CRM, by mass.

The combined materials shall be reacted for a minimum of 45 minutes after incorporation of the CRM and maintained at a temperature between 375°F and 425°F. The temperature shall be at least 45°F below the actual flash point of the asphalt-rubber binder.

If any of the material in a batch of asphalt-rubber binder is not used within 4 hours after the 45-minute reaction period, heating of the material shall be discontinued. Any time the asphalt-rubber binder cools below 375°F and is reheated shall be considered a reheat cycle. The PG 64-28WP shall not be reheated more than twice. The material shall be uniformly reheated to a temperature between 375°F and 425°F prior to use. Additional scrap tire CRM may be added to the reheated binder and reacted for a minimum of 45 minutes. The cumulative amount of additional scrap tire CRM shall not exceed 10 percent of the total binder mass. Reheated asphalt-rubber binder shall conform to the provisions for PG 64-28WP.

During the injection process of the PG 64-28WP into the plant, the Contractor shall take viscosity readings of asphalt-rubber binder from samples taken from the feed line connecting the storage and reaction tank to the HMA plant. The readings shall be taken at least every hour with at least one reading for each batch of asphalt-rubber binder. The Contractor shall log these results, including time and asphalt-rubber binder temperature, and a copy of the log shall be submitted to the Engineer daily. The Contractor shall either notify the Engineer at least 15 minutes prior to each test or provide the Engineer a schedule of testing times. The Contractor shall immediately notify the Engineer if any viscosity reading falls below 1.0 Pa·s when tested at 350°F.

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Subsection 401.15 shall include the following:

The minimum mix discharge temperature for PG 64-28TB and PG 64-28WP shall be 320°F. The minimum delivered mix temperature for PG 64-28TB and PG 64-28WP shall be 280°F.

Subsection 401.17 shall include the following:

Further compaction effort shall not be applied to HMA containing PG 64-28TB or PG 64-28WP when the surface temperature of the mixture falls below 230 °F.

Subsection 401.22 shall include the following:

Facilities for blending and storing PG 64-28WP will not be measured and paid for separately, but shall be included in the work. Facilities for storing PG 64-28TB will not be measured and paid for separately, but shall be included in the work.

Subsection 403.02 shall include the following:

The design mix for hot mix asphalt shall conform to the following:

Table 403-1

Property	Test Method	Value For Grading	
		SX(100)	SX(100)
Air Voids, percent at: N (design)	CPL 5115	3.5 – 4.5	3.5 – 4.5
Lab Compaction (Revolutions): N (design)	CPL 5115	100	100
Stability, minimum	CPL 5106	30	30
Aggregate Retained on the 4.75 mm (No. 4) Sieve with at least 2 Mechanically Induced fractured faces, % minimum	CP 45	60	60
Accelerated Moisture Sus- ceptibility Tensile Strength Ratio (Lottman), minimum	CPL 5109 Method B	80	80
Minimum Dry Split Tensile Strength, kPa (psi)	CPL 5109 Method B	205 (30)	205 (30)
Grade of Asphalt Cement, Top Layer		PG 64-28TB	PG 64-28WP
Voids in the Mineral Aggregate (VMA) % minimum	CP 48	See Table 403-2	See Table 403-2
Voids Filled with Asphalt (VFA), %	AI MS-2	65 - 75	65 - 75
Dust to Asphalt Ratio Fine Gradation Coarse Gradation	CP 50	0.6 – 1.2 0.8 – 1.6	0.6 – 1.2 0.8 – 1.6

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- Note: AI MS-2 = Asphalt Institute Manual Series 2
- Note: The current version of CPL 5115 is available from the Region Materials Engineer.
- Note: Mixes with gradations having less than 40% passing the 4.75 mm (No. 4) sieve shall be approached with caution because of constructability problems.
- Note: Gradations for mixes with a nominal maximum aggregate size of one-inch or larger are considered a coarse gradation if they pass below the maximum density line at the #4 screen. Gradations for mixes with a nominal maximum aggregate size of ¾ inch or smaller are considered a coarse gradation if they pass below the maximum density line at the #8 screen.

All mix designs shall be run with a gyratory compaction angle of 1.25 degrees and properties must satisfy Table 403-1. Form 43 will establish construction targets for Asphalt Cement and all mix properties at Air Voids up to 1.0 percent below the mix design optimum.

Table 403-2

Minimum Voids in the Mineral Aggregate (VMA)			
Nominal Maximum Size*, mm (inches)	***Design Air Voids **		
	3.5%	4.0%	4.5%
37.5 (1½)	11.6	11.7	11.8
25.0 (1)	12.6	12.7	12.8
19.0 (¾)	13.6	13.7	13.8
12.5 (½)	14.6	14.7	14.8
9.5 (⅜)	15.6	15.7	15.8

* The Nominal Maximum Size is defined as one sieve larger than the first sieve to retain more than 10%.

** Interpolate specified VMA values for design air voids between those listed.

*** Extrapolate specified VMA values for production air voids beyond those listed.

The Contractor shall prepare a quality control plan outlining the steps taken to minimize segregation of HMA. This plan shall be submitted to the Engineer and approved prior to beginning the paving operations. When the Engineer determines that segregation is unacceptable, the paving shall stop and the cause of segregation shall be corrected before paving operations will be allowed to resume.

A minimum of 1 percent hydrated lime by weight of the combined aggregate shall be added to the aggregate for all hot mix asphalt.

Acceptance samples shall be taken at the location specified in either Method B or C of CP 41, as determined by the Engineer.

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Subsection 403.03 shall include the following:

The Contractor shall construct the work such that all roadway pavement placed prior to the time paving operations end for the year, shall be completed to the full thickness required by the plans. The Contractor's Progress Schedule shall show the methods to be used to comply with this requirement.

Subsection 403.05 shall include the following:

The accepted quantities of hot mix asphalt will be paid for in accordance with subsection 401.22, at the contract unit price per ton for the bituminous mixture.

Payment will be made under:

Pay Item	Pay Unit
Hot Mix Asphalt Grading SX(100)PG 64-28TB	Ton
Hot Mix Asphalt Grading SX(100)PG 64-28WP	Ton

Aggregate, asphalt recycling agent, additives, hydrated lime, and all other work necessary to complete each hot mix asphalt item will not be paid for separately, but shall be included in the unit price bid. When the pay item includes the PG binder grade, the asphalt cement will not be measured and paid for separately, but shall be included in the work.

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In subsection 702.01(a) add Table 702-1A which shall include the following:

**Table 702-1A
Rubberized Asphalt Binder**

Property	Test Method	Specification Grade	
		PG64-28TB	PG 64-28WP
Original Binder			
Flash Point, Minimum °C	T48	230	230
Solubility, Minimum %	T44	90	80
% Rubber Content, %, min.	-	5	5
Viscosity at 135°C, Maximum, Pa·s	T316	3.0	3.0
Dynamic Shear, Test Temp. at 10 rad/s, °C Minimum G*/sin(delta), kPa	T315	64 1.00	64 1.00
Ductility @ 4 °C, 5cm/min, cm, Min.	T 51	Report	Report
Toughness, joules (inch-lbs)	CP-L 2210	Report	Report
Tenacity, joules (inch-lbs)	CP-L 2210	Report	Report
RTFO Test Aged Binder			
Mass Loss, Maximum, %	CP-L 2215	1.00	1.00
Dynamic Shear, Test Temp. at 10 rad/s, °C Minimum G*/sin(delta), kPa	T315	64 2.20	64 2.20
Ductility @ 4 °C, 5cm/min, cm, Min.	T 51	Report	Report
PAV Aging, Temperature, °C	R28	100	100
RTFO Test and PAV Aged Binder			
Dynamic Shear, Test Temp. at 10 rad/s, °C Minimum G*/sin(delta), kPa	T315	22 5000	22 5000
Creep Stiffness, Test Temperature, °C Maximum S-value, MPa Minimum M-value	T313	-18 300 0.300	-18 300 0.300

The binder formulations for PG 64-28TB and PG 64-28WP shall include the following information:

1. Paving Asphalt and Modifiers:
 - (a) Source and grade of paving asphalt.
 - (b) Source and identification (or type) of modifiers used.
 - (c) Percentage of the combined blend of paving asphalt and asphalt modifier by total mass of asphalt-rubber binder to be used.

2. Crumb Rubber Modifier (CRM):
 - (a) Source and identification (or type) of scrap tire CRM.
 - (b) Percentage of scrap tire CRM by total mass of the asphalt-rubber blend.
 - (c) If CRM from more than one source is used, the above information is required for each CRM source used.

3. Asphalt-Rubber Binder: The minimum temperature and minimum reaction time in the storage vessel.

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The paving asphalt and asphalt modifier shall be combined into a blended mixture that is chemically compatible with the crumb rubber modifier to be used. The tire rubber shall not settle or phase separate.

PG 64-28TB shall not be diluted with extender oil, kerosene, or other solvents. PG 64-28TB asphalt binder so contaminated shall not be used. Kerosene or other solvents used in the cleaning of equipment shall be purged from the system prior to subsequent use of that equipment.

Subsection 702.01 shall include the following:

(c) *Crumb rubber modifier (CRM)*. Crumb rubber modifier (CRM) shall consist of scrap tire CRM. The scrap tire CRM shall consist of ground or granulated rubber derived from of automobile tires, truck tires, tire buffing, or a combination thereof. Steel and fiber separation may be accomplished by any method. Cryogenic separation, if utilized, shall be performed separately and shall be prior to grinding or granulating. CRM shall be ground or granulated at ambient temperature. Cryogenically produced CRM particles which can pass through the grinder or granulator without being ground or granulated respectively shall not be used. CRM shall not contain more than 0.01 percent wire (by mass of CRM) and shall be free of other contaminants, except fabric. Fabric shall not exceed 0.05 percent by mass of CRM. A Certificate of Compliance certifying these percentages shall be furnished to the Engineer in conformance with the subsection 106.12. The CRM shall contain less than 0.75% moisture by weight when tested in accordance with ASTM D 1864 at $221 \pm 9^\circ\text{F}$ and shall be free flowing and not produce foaming when combined with the blended paving asphalt and asphalt modifier mixture. Calcium carbonate or talc may be added at a maximum amount of 3 percent by mass of CRM to prevent CRM particles from sticking together. The CRM shall have a specific gravity between 1.1 and 1.2 when tested in accordance with AASHTO T-227. Scrap tire CRM shall be delivered to the production site in separate bags and will be sampled and tested separately. CRM material shall conform to the following requirements of ASTM D 297:

SCRAP TIRE CRUMB RUBBER MODIFIER

Test Parameter	Percent	
	Min.	Max.
Acetone Extract	6.0	16.0
Ash Content	—	8.0
Carbon Black Content	22.0	38.0
Rubber Hydrocarbon	42.0	65.0

The CRM for asphalt-rubber binder shall conform to the gradations specified below when tested in conformance with the requirements in ASTM C 136, except as follows:

1. Split or quarter $100 \text{ g} \pm 5 \text{ g}$ from the CRM sample and dry to a constant mass at a temperature between 130°F and 145°F and record the dry sample mass. Place the CRM sample and 5.0 g of talc in a 0.5-L jar. Seal the jar: then shake it by hand for a minimum of one minute to mix the CRM and the talc. Continue shaking or open the jar and stir until particle agglomerates and clumps are broken and the talc is uniformly mixed.
2. Place one rubber ball on each sieve. Each ball shall have a mass of $8.5 \text{ g} \pm 0.5 \text{ g}$, have a diameter of $24.5 \text{ mm} \pm 0.5 \text{ mm}$, and shall have a Shore Durometer "A" hardness of 50 ± 5 in conformance with the requirements in ASTM Designation: D 2240. After sieving the combined material for $10 \text{ minutes} \pm 1 \text{ minute}$, disassemble the sieves. Material adhering to the bottom of a sieve shall be brushed into the next finer sieve. Weigh and record the mass of the material retained on the $850 \text{ }\mu\text{m}$ sieve and leave this material (do not discard) on the scale or balance.

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Observed fabric balls shall remain on the scale or balance and shall be placed together on the side of the scale or balance to prevent the fabric balls from being covered or disturbed when placing the material from finer sieves onto the scale or balance. The material retained on the next finer sieve (425 μm sieve) shall be added to the scale or balance. Weigh and record that mass as the accumulative mass retained on that sieve (425 μm sieve). Continue weighing and recording the accumulated masses retained on the remaining sieves until the accumulated mass retained in the pan has been determined. Prior to discarding the CRM sample, separately weigh and record the total mass of fabric balls in the sample.

3. To account for the 5 g of talc added to the sample, determine the mass of passing the 150 μm sieve (or mass retained in the pan) by subtracting the accumulated mass retained on the 150 μm sieve from the accumulated mass retained in the pan. If the material retained in the pan has a mass of 5 g or less, cross out the recorded number for the accumulated mass retained in the pan and copy the number recorded for the accumulated mass retained on the 150 μm sieve as the accumulated mass retained in the pan. If the material passing the 150 μm sieve (or mass retained in the pan) has a mass greater than 5 g, cross out the recorded number for the accumulated mass retained in the pan, subtract 5 g from that number and record the difference next to the crossed out number.

CRM GRADATIONS

Sieve Size	Scrap Tire CRM Percent Passing
No. 20 (850 μm)	100
No. 40 (425 μm)	85-100
No. 60 (180 μm)	10-50
No. 80 (150 μm)	5-30