

SECTION 823 HOT-MIX, HOT-LAID BITUMINOUS CONCRETE

823.01 Description. This material consists of hot-mix, hot-laid bituminous concrete bases and surface courses.

MATERIALS.

823.02 Asphalt Cement. The asphalt cement shall be AC 20 with a viscosity grade conforming to the requirements of [Section 810](#). Tank trucks used to deliver asphalt cement shall be equipped with an approved sampling device. The delivery temperature of the material shall not exceed the maximum mixing temperature.

823.03 Fine Aggregate. Fine aggregate is defined as all material passing the No. 8 (2.36 mm) sieve and shall consist of clean, hard, durable crushed stone.

In Job Mix Formula Types B, C, and D, which are defined in [Subsections 823.19](#), [823.20](#), and [823.21](#), up to 15% of the fine aggregate may be washed concrete sand, conforming to the requirements of Section 804. If the stability, as determined by the Laboratory Marshall Method in accordance with AASHTO T 245, is less than 1200 lb (5.3 kN), the fine aggregate sand percentage shall be reduced or excluded. All carbonate and serpentine aggregate shall be prohibited in the final roadway wearing surface course on any roadway having a minimum average daily traffic volume (ADT) of 8000 vehicles and a posted speed of 35 mph (60 km/h) or greater.

823.04 Coarse Aggregate. Coarse aggregate shall be all material retained on the No. 8 (2.36 mm) sieve and shall conform to the requirements of [Section 805](#). All carbonate and serpentine aggregate shall be prohibited in the final roadway wearing surface course on any roadway having a minimum average daily traffic volume (ADT) of 8000 vehicles and a posted speed of 35 mph (60 km/h) or greater.

823.05 Antistripping Additive. When specified for use by the Engineer, or when the Tensile Strength Ratio (TSR) is less than 80 as determined in accordance with AASHTO T 283, a heat-stable, antistripping chemical additive conforming to the requirements of Section 829 shall be blended with the asphalt cement in accordance with [Subsection 823.16](#).

823.06 Laboratory. At all batch and dryer drum mixing plants, the Contractor shall provide a building suitable for afield laboratory in which to house and use the equipment necessary to carry on the various tests required, including bituminous extractions and gradations.

The building shall be for the use of the Engineer and inspectors for testing and recording purposes and shall be so located that activities at the plant are plainly visible from one window of the building.

The building shall have a minimum of 600 ft² (55 m²) of floor space and be of acceptable dimensions. It shall be weatherproof and have at least two windows and a door, all equipped with acceptable latches and locks. The building shall be maintained to the satisfaction of the Engineer. Satisfactory lighting, heating, and air conditioning shall be supplied. The air conditioning equipment shall be capable of maintaining the room temperature throughout the laboratory at 77 ° (25 °C) at all times.

The Contractor shall furnish all water, including drinking water, fuel, telephone, heat, and power to conduct all necessary tests. Tables, desks, chairs, and work tables shall be provided and maintained as required. Approved sanitary facilities shall be furnished and maintained.

If approved, the laboratory may be a part of another building, in which case it shall be completely partitioned off from the remainder of the building.

823.07 Testing Equipment. All production plants shall be equipped with all the necessary equipment from the equipment list supplied by the Department's Materials and Research Section. The Contractor shall ensure that the laboratory contains equipment of approved make and design and shall maintain the equipment to the satisfaction of the Engineer.

Approval of the plant will be contingent upon meeting the requirements of [Subsection 823.06](#) and this Subsection.

823.08 Inspection of Mixing Plant Operations. The Engineer or the Engineer's representative shall have access at all times to all parts of the mixing plant for checking the adequacy of the equipment in use, inspecting the conditions and operation of the plant, verifying the weights or proportions and character of materials, and determining and checking the temperatures being maintained in the preparation of the mixtures.

MIXING PLANTS.

The two types of mixing plants are Batch Type and Continuous Mixing Type.

823.09 Batch Type. Bituminous concrete plants will not be approved unless they are automated.

The automatic batch plant shall be controlled by means of an approved automatic batch selector. The batch selector shall control and deliver, accurately and in proper sequence, the designated weight or volume of bituminous material and aggregates required for the bituminous concrete mixture and shall automatically time the mixing operation. The batch selector controls shall be locked or sealed during the operation, and no changes in selector control or setting shall be made except in the presence of the Engineer's representative.

- a. *Interlocks.* The plant shall be equipped with interlocking cut-off circuits to interrupt and stop the automatic cycling of the operation at all times when errors in weighing or proportioning occur, or when there is a malfunction of any portion of the control system.
- b. *Equipment Failure.* If the automatic proportioning devices become inoperative, the plant may be permitted to batch and mix bituminous materials for a period of not more than 48 hours from the time of the breakdown, if approved by the Engineer. Written permission of the Engineer shall be required for a period of operation longer than 48 hours without automatic proportioning.

823.10 Plant and Machinery. The mixing plant used by the Contractor in preparation of the bituminous concrete shall be capable of producing a minimum of 75 tons (68 metric tons) per operating hour and shall comply with the following requirements:

- a. *Cold Feed.* The plant shall be provided with a separate cold bin or tunnel opening for each size and type of mineral aggregate used in the mix. In addition, each cold bin or tunnel opening shall be equipped with a calibrated gate and mechanical feed to provide a uniform and concurrent flow of aggregates prior to their introduction into the drier.
- b. *Drier.* The drier shall be a rotating cylinder type suitably designed to heat and dry the aggregates, and shall continually agitate the aggregates during heating. The drier shall be capable of preparing aggregate to the full rated capacity of the paving plant.
- c. *Burner.* The burner shall be of an approved design and shall be automatically controlled.
- d. *Sieves.* All plant sieves shall be designed, constructed, and operated so that all aggregates are sieved to their specified sizes and proportions, and shall have a capacity, when operated at normal speed, slightly in excess of the maximum capacity of the mixer.
- e. *Bins.* The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to ensure separate and adequate storage of appropriate fractions of the mineral aggregates, and the plant shall be equipped to feed such

material into the mixer within "0.5% of the total batch weight. Separate dry storage shall be provided for filler or hydrated lime when used, and the plant shall be equipped to feed such material into the mixer within "0.5% of the total batch weight. Each bin shall be provided with overflow pipes, sized and located to prevent material backing up into other compartments or bins. Each compartment shall be provided with an individual outlet gate that prevents leakage when closed. The gates shall cut the flow off quickly and completely. Bins shall be constructed so that samples can be readily obtained. Bins for continuous mix plants shall be equipped with adequate telltale devices to indicate the position of the aggregates in the bins at the lower quarter points. Each compartment shall be designed to prevent the overflow of material into other bins.

- f. *Weigh Box or Hopper.* The plants shall have a weigh box of sufficient capacity to hold the maximum amount of the aggregate material for one batch. The weigh box or hopper shall be supported on fulcrums and knife edges, and constructed such that it can not be easily thrown out of alignment or adjustment. Weighing hoppers must be free from contact with all edges, ends, sides, supporting rods or columns, or with other equipment that will in any way affect their proper functioning. In addition, there must be sufficient clearance between the hopper and supporting devices so that foreign materials will not accumulate. The discharge gate of the weigh box must be positioned to prevent aggregate separation when dumping in the mixer. If necessary, baffles shall be inserted or other means provided to discharge the materials in a blended condition.
- g. *Aggregate Scales.* Scales for the weighing of aggregates shall be of standard make and design and shall be accurate to 0.5% throughout their range. The scale shall consist of a digital readout connected to a load cell. All digital readouts shall be so located that they will be in plain view of the operator and the Engineer or the Engineer's agent. No weighing of aggregates shall be permitted where vibration from the plant mechanisms or any other source prevents accurate reading of the scale. The value of the graduations of scales weighing over 5000 lb (2250 kg) shall not be greater than 0.1% of the rated capacity of the scale.
- h. *Bitumen Scales.* The digital scale shall have a capacity of at least 15% in excess of the quantity of bituminous material used in a batch. The controls shall be constructed so that they may be locked at any setting and automatically reset to the reading after the addition of bituminous material to each batch. The readout shall be in full view of the mixer operator and the Engineer and the Engineer's agent and shall be graduated in increments not greater than 1 lb (0.45 kg). The flow of bituminous material shall be automatically controlled. All of the bituminous material required for one batch shall be discharged in not more than 20 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of bituminous material the full length of the mixer. The section of the bituminous line between the charging valve and spray bar shall be provided with a valve and outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

The equipment used to measure the bituminous material shall be accurate to "0.5%. The bituminous material bucket shall be a non-tilting type with a loose sheet metal cover. The length of the discharge opening or spray bar shall be adequately heated. The capacity of the bituminous material bucket shall be at least 15% in excess of the weight of bituminous material required in any batch. The plant shall have an adequately heated, quick acting, non-drip, charging valve located directly over the bituminous material bucket.

- i. *Test Weights.* The Contractor shall provide and have readily available at least 10 standard 50 lb weights (eleven standard 20 kg, one standard 5 kg, and two standard 1 kg weights), for checking the scales during operations.

The weighing equipment, in addition to complying with the above requirements, must have adjusting devices which will provide for the readjustment of any part that, being out of adjustment or balance, prevents the scale from functioning properly.

- j. *Asphalt Control System.* The proper amount of bituminous material in the mix, within the tolerance specified for the job mix, shall be provided by either weighing or metering.

Heating of asphalt cement shall be by steam coil, hot oil, or other approved methods. Under no

circumstances shall a flame from oil or other fuel be permitted to come in direct contact with the heating tanks. The asphalt circulating system shall be sized to give proper and continual circulation of asphalt cement throughout the operating periods.

- k. *Thermometric Equipment.* An armored thermometer, reading within the ranges used, shall be fixed in the asphalt line at a suitable location near the weigh bucket discharge valve.

The plant shall also be equipped with an approved dial scale thermometer and an electric pyrometer or other approved thermometric instrument placed at the discharge chute of the drier to automatically register and record the temperature of the heated aggregates. This device shall also be in full view of the burner controller or the head feeder.

The Engineer reserves the right to judge the efficiency of the above instruments and direct the replacement of the instruments with some approved temperature recording apparatus. Further, the Engineer may require the Contractor to submit daily charts of the recorderNs readings.

- l. *Mixer Unit.* The mixer shall be a heat-jacketed, insulated, batch mixer, of the standard pugmill type, or an approved heat-jacketed, insulated, rotary drum-type mixer. Rotary mixers shall be equipped with a sufficient number of paddles or blades set in position to produce properly mixed batches of any material required under these Specifications. When the clearance in the twin pugmill exceeds 10 (25 mm), either the shortened blades or the worn liners (or both) shall be replaced to reduce the clearance to less than the allowable 10 (25 mm) maximum. The mixer shall be provided with an approved, accurate time lock that will lock the discharge gates until the specified mixing time has elapsed. In no case shall the rated capacity of the mixer specified on the manufacturerNs name plate be exceeded. If sufficient mixing and coating is not obtained, the Engineer reserves the right to direct the Contractor to increase the mixing time.

Deviations in sizes of batches will be permitted to provide for mixing batches 25% below the rated capacity of the mixer. When slag coarse aggregate is used, no increase will be permitted in the size of the batch above the rated capacity of the mixer.

- m. *Dust Collector.* All plants shall be equipped with an approved dust collector system. Provisions shall be made to waste the collected material or to return it uniformly to the aggregate mixture as directed. All State and local air pollution control regulations and ordinances shall be followed.
- n. *Safety Requirements.* An adequate and safe stairway to the mixer platform and guarded ladders shall be placed at all points required for accessibility to all plant operations. All gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading space, and this space shall be kept free of drippings from the mixing platform. A platform shall be located at the truck loading space to permit easy and safe inspection of the mixture as it is delivered into the trucks. The platform and steps shall have safety handrails. Easy and safe access shall be provided to the location above the mixer where sampling of the aggregate in the bins is to take place. Adequate overhead protection shall be provided where necessary. All other Federal, State, or local safety requirements shall be followed.
- o. *Platform Truck Scales.* All plants shall be equipped with platform truck scales to weigh empty and loaded trucks. Truck scales shall be of approved design and kept in good condition. Scales shall be mounted in a concrete foundation that will ensure their remaining level and plumb. Scales shall be mounted to weigh the entire truck. All platform truck scales shall be approved by the appropriate Sealer of Weights and Measures and have seals attached at the beginning of each season or at such other times, as may be deemed necessary. ManufacturerNs Certified Scale Checks may be accepted. Split weighing will not be approved.

823.11 Continuous Mixing Type. The use of continuous mixing plants will be permitted for the preparation of hot-mix bituminous concrete, provided such plants conform to the requirements listed below and to the general requirements for all plants.

- a. *Gradation Control Unit.* The plant shall include a means for accurately proportioning each size of aggregate by either weighing or volumetric measurement. When gradation control is by volume, the plant shall include feeders mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to provide an orifice for volumetrically measuring the material drawn from each bin compartment. The orifice shall be rectangular with one dimension adjustable by a positive mechanical means, and shall be provided with a lock. Indicators shall be provided in each gate to show the gate opening in millimeters.
- Mineral filler, if specified, shall be proportioned separately and added to the mix to obtain uniform distribution.
- b. *Weight Calibration of Bitumen and Aggregate Feed.* The plant shall include a means of calibrating gate openings and meters using weight test samples. The aggregate fed out of the bins through individual orifices shall be bypassed to a suitable test box, confining the material from each compartment in a separate box. The plant shall be equipped to conveniently handle test samples weighing up to 800 lb (360 kg) and to weigh them on accurate scales. Means shall be provided for calibrating the flow of bitumen.
- c. *Synchronization of Aggregate and Bitumen Feed.* Positive interlocking control between the flow of aggregate from the bins and the flow of bitumen from the meter or other proportioning source shall be provided. This device shall include a mechanical interlock or other positive method of accurate control.
- d. *Mixer Unit Continuous Method.* The plant shall include a continuous mixer of an approved twin pugmill type, heat-jacketed, and capable of producing a uniform mixture within the permissible variations from the job mix specifications. The angular position of the paddles on the shafts shall be adjustable, and the paddles shall be reversible to retard the flow of the mix. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge and the rate of feed of aggregate per minute at plant operating speed.

Unless otherwise required, determination of mixing time shall be by the weights method under the following formula. The weights shall be determined for the job by tests made by the Engineer

$$\text{Mixing Time (s)} = \frac{\text{Pugmill Dead Capacity In Pounds (kg)}}{\text{Pugmill Output In Pounds per Second (kg/s)}}$$

The production capacity of the continuous mix plant shall be not less than 75 tons (70 metric tons) per hour 42 lb/s (19 kg/s).

- e. *Discharge Hopper.* The discharge end of the pugmill shall be equipped with a hopper, or other approved device for truck loading, that will eliminate segregation of the mixed material.

PROCEDURE FOR BATCH OR CONTINUOUS TYPE PLANTS.

823.12 Preparation of Asphalt Cement. All asphalt cement shall be uniformly heated in tanks to a temperature of 250 to 350 °F (120 to 175 °C). Asphalt shall be maintained within these temperature limits.

823.13 Preparation of Mineral Aggregates. Before entering the mixer, the aggregates shall be dried and heated to a temperature of not more than 375 °F (190 °C), except for recycled mixes. Flames used for drying and heating shall be properly adjusted to avoid injury to the aggregate.

Immediately after heating, the aggregates shall be screened into separate bins, ready for batching and mixing with asphalt cement.

823.14 Preparation of the Mixture. Each size of hot aggregate and the asphalt cement shall be weighed separately to accurately determine the correct portion of each constituent in the mix. The mixing temperature and tolerance will be given by the Department's Materials and Research Section for the type of material being produced.

The mixture shall consist of coarse aggregate, fine aggregate, mineral filler if required, and asphalt cement. The exact proportions within the limits specified shall be regulated to produce a satisfactory non-boiling mixture with all the particles fully coated.

After the hot fine and coarse aggregates are introduced into the twin pugmill, a minimum dry mix time of 6 seconds shall be required unless otherwise directed by the Engineer. The asphalt cement shall be added in an even sheet the full width of the mixing chamber. After the asphalt cement is added, mixing shall be continued for a minimum of 30 seconds, or until the aggregates are coated and well mixed.

The processed bituminous concrete mixture may be held in an approved storage system in accordance with [Subsection 823.17](#).

823.15 Dryer-Drum Mixers. The plant shall be specifically designed for dryer-drum mixing and shall be capable of satisfactorily heating, drying, and mixing the bituminous mixtures. The aggregate shall enter the drum from the burner-end and shall travel parallel to the flame and the exhaust air stream. The system shall be equipped with automatic burner controls. Heating shall be controlled to prevent damage to the aggregate or the asphalt cement. The temperature of the mixture when discharged from the mixer shall be within the range specified by the Department's Materials and Research Section for the type mix being produced. The rate of flow through the drum shall be controlled to obtain a homogeneous mixture with uniformly-coated particles. In no case shall the quantity of mixture produced exceed the manufacturer's rated capacity.

Each cold feed bin shall have an adjustable gate with an indicator to reference the opening setting. A device shall be installed on each of the aggregate feeders to indicate when the flow of material from the bin is not sufficient to allow accurate proportioning through the feeder gates. These indicators shall be positive in action and shall actuate a clearly visible or audible signal to attract the plant operator's attention, and they shall stop the flow of materials to the drum when the level of material in the bin is too low for accurate proportioning. In addition, for those particular cold bins in which aggregate material tends to either bridge or lump together causing temporary interruptions in feeds, a vibrator or other suitable means shall be provided to ensure uniform flow out of bins so that aggregate material does not bridge or lump. All cold feed bins including mineral filler silos shall be accurate to 0.5% of the total weight delivered by that particular bin or silo. The order of aggregate feed onto the composite cold feed belt shall be from coarse to fine. An independently mounted scalping screen shall be installed if directed by the Engineer.

Asphalt cement shall be introduced through a continuously registering, cumulative indicating meter by a pump specifically designed for dryer-drum plants. The meter shall be located in the asphalt line to continuously register the asphalt discharge to the mixer and arranged to allow diversion of the discharge through the meter to a container for measurement. The meter shall be equipped with a nonsetback register and shall have an accuracy within 1% by weight of the material actually being measured in any given period of time. The temperature of the asphalt shall be monitored by a thermocouple which shall be calibrated prior to the annual asphalt feed calibration to within 4 EF (2 EC) of a certified mercury thermometer and shall have a digital display on the control panel. The accuracy of the pump and meter shall be verified annually and whenever designated by the Engineer with the Engineer's agent present to document the calibration.

The aggregate feed and the asphalt flow systems shall be interlocked by a blending system that automatically regulates the asphalt flow and immediately corrects for variations in aggregate flow. The system shall provide positive weight measurement of the combined cold aggregate feed by use of a belt scale. The combined cold aggregate feed shall be continuously recorded on a nonsetback register. Feed of material to

the belt scale shall be controlled to ensure that the combined aggregate flow is between 50 and 100% of the rated capacity of the scales at normal operation. The plant shall be equipped so that the proportion of each aggregate can be individually varied. The plant shall also be equipped so that the total aggregate rate can be varied without affecting the proportions. The plant shall be equipped with a moisture compensating device in the control panel to automatically correct for the moisture in the aggregate passing over the belt scale. The plant shall be required to use the most recent moisture values obtained to ensure accurate asphalt proportioning. Moisture determinations for the combined aggregate will be made periodically during each dayNs operation. The plant shall also be equipped with a device in the control panel to automatically correct for the specific gravity of the asphalt.

Safe, adequate, and convenient facilities shall be provided for obtaining representative asphalt and aggregate samples. The plant shall be equipped with a sampling device capable of providing a sample of sufficient size from the full width of the combined aggregate cold feed flow. The sampling device shall be designed so that samples may be taken while the plant is operating at normal production rates. Safe, adequate, and convenient facilities shall be provided for calibrating the asphalt flow and the aggregate flow. The manufacturerNs recommendations shall be followed for calibration. To calibrate the aggregate flow system, means shall be provided to permit a positive and uniform diversion of the aggregate in sufficient quantity to accurately check the weight of aggregate per period of time. To calibrate the asphalt metering system for proper proportioning, an asphalt distributor or other equipment approved by the Engineer shall be made available so that accurate tare, gross, and net weights may be obtained for the diverted asphalt discharge. The rate of flow of the total aggregate and asphalt flow shall not vary by more than 2.0% by weight from the required quantity of each.

The dryer-drum mixer shall be capable of simultaneously heating and mixing the introduced aggregate and asphalt to produce an acceptable, thoroughly coated mix meeting the required temperature and mix designs. Pyrometers or other thermometric instruments shall be located at the discharge chute of the dryer-drum mixer to automatically register the temperature of the mix.

Prior to mixing of hot-mix bituminous concrete in drum mix plants, the gradation of all stockpiled aggregate material shall be checked for grading requirements conforming to [Section 813](#) and shall be approved prior to use. Aggregate from the approved stockpiles shall be selected based on a percentage of the stockpile sizes to meet the appropriate job mix formula gradation according to [Subsections 823.20](#), [823.23](#), and [823.24](#). Samples from the cold feed conveyor shall be taken to ensure that the proper gradation requirements are being met prior to the addition of asphalt for production of hot-mix.

823.16 Anti-stripping Additive Blending - All Plants. Blending of the additive and asphalt cement shall be accomplished at the bituminous concrete production plant during the production of bituminous material, through the use of an approved in-line metering and blending system. The holding tank shall be thermostatically controlled for heat and shall have a re-circulating line for uniform heat control. The additive temperature shall be maintained at a uniform mix temperature at least 24 hours prior to production to ensure uniform additive viscosity. There shall be a diverter valve in the re-circulating line from the pump for calibration purposes, which shall deliver a full stream from the additive pump at a height equivalent to the addition input to the main asphalt line. Additive pumps shall be calibrated on a daily basis or whenever deemed necessary by the Engineer. The calibration shall be done by plant personnel and witnessed by a representative of the DepartmentNs Materials and Research Section.

823.17 Storage Systems - All Plants. The system shall be capable of conveying the hot-mixture from the plant to the storage bins and storing the hot-mixture without a reduction in temperature and with no segregation of the mix or oxidation of the asphalt. The mixture, as delivered for the work, shall comply with all specified quality requirements.

The conveyor system may be either a continuous or skip bucket type. The continuous type shall be enclosed and heated to effectively control the mix temperature. The skip bucket type must be large enough to transport and mass dump an entire batch into the bins.

The storage bins shall be designed to prevent segregation of the mix during discharge from the conveyor into the bins. The bin discharge gates shall be designed to prevent segregation of the hot-mixture while loading into trucks.

Approval for the use of storage bins may be withdrawn when excessive heat gain or loss, uneven heating, segregation of the aggregate, or migration or oxidation of the asphalt occurs due to the operation or use of storage bins. Mixtures may be retained in heated storage bins for 12 hours, provided that material and mixture qualities are maintained.

MIXTURE REQUIREMENTS.

823.18 Applicable Testing Methods. The following standards shall be used to test the qualities of the mixture.

- AASHTO T 164 Method A, Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
- AASHTO T 166 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
- AASHTO T 209 Maximum Specific Gravity of Bituminous Paving Mixtures
- AASHTO T 245 Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
- AASHTO T 269 Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
- AASHTO T 283 Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
- AASHTO T 287 Asphalt Cement Content of Asphalt Concrete Mixtures by the Nuclear Method

Samples of the actual mixture in use will be taken as many times daily as determined by the Engineer. The mixture must be maintained uniform throughout the Project within the above tolerances. Should the mix produced not meet the above requirements or the Contract performance needs, changes in the mix design or mixing procedure shall be made immediately in a manner approved by the Engineer.

If an additional source of supply for materials is submitted and approved, the job mix formula shall be readjusted as necessary by the Contractor and submitted to the Engineer. All job mix formulas submitted and found unacceptable shall be readjusted to the satisfaction of the Engineer.

823.19 Job Mix Formula Types A, B, C, D, and E. The general composition limits prescribed in this Section are master ranges of tolerance to govern mixtures made from all raw materials conforming to the requirements of [Sections 804](#) and [805](#). The composition limits are maximum and minimum in all cases. Closer control may be required for job materials used for specific projects according to the job mix formula. No work shall be started on the Contract, and no mixture will be accepted for the work, until the proposed job mix formula has been approved. The Contractor shall submit a written proposal indicating the single definite percentage for each sieve fraction of aggregate and for the asphalt that the Contractor chooses as the fixed percentage for each component in the mix. The proposal shall also indicate the temperature at which the Contractor shall furnish the mixture at the plant. The approval of the job mix formula shall bind the Contractor to furnish paving mixtures that not only meet the master ranges, but also meet the exact formula set for the Project, within the allowable tolerances.

823.20 Gradation for Job Mix Formula Types A, B, C, D, and E.

Sieve Size	Type A (%)	Type B (%)	Type C (%)	Type D & E (%)	Job Mix Tolerance (%)
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22" (63 mm)	100	---	---	---	"7
2" (60 mm)	90 - 100	---	---	---	"7
12" (37.5 mm)	60 - 90	---	---	---	"7
13" (31.5 mm)	---	100	---	---	"7
1" (25.0 mm)	40 - 75	95 - 100	---	---	"7
3/4" (19.0 mm)	---	75 - 95	---	---	"7
1/2" (12.5 mm)	30 - 65	50 - 85	100	---	"7
3/8" (9.5 mm)	---	45 - 70	85 - 100	100	"7
#4 (4.75 mm)	20 - 45	30 - 50	50 - 75	80 - 100	"7
#8 (2.36 mm)	---	22 - 38	33 - 59	70 - 90	"4
#30 (600 Fm)	---	9 - 23	14 - 32	30 - 55	"4
#50 (300 Fm)	---	6 - 18	7 - 26	15 - 40	"4
#200 (75 Fm)	2 - 10	3 - 10	3 - 10	5 - 15	"2
A.C., %	2.0 - 4.0	3.5 - 5.5	4.5 - 6.5	6.0 - 8.5	"0.4
Temp. EF	225 - 275	275 - 325	275 - 325	275 - 325	"20EF
Temp. EC	(107 - 135)	(135 - 163)	(135 - 163)	(135 - 163)	"11

The percentages for aggregates are based on the total weight of aggregate. The percentages for asphalt cement are based on the total weight of the mix.

Washed gradations of final products shall be used to determine the amount of No. 200 (75 μ m) material. The washed dust to effective asphalt ratio shall be between 0.6 and 1.2 for the final mixture.

823.21 Marshall Properties for Job Mix Formula Types A, B, C, D, and E.

Specification Requirements	Mix Type			
	A	B	C	D & E
Air Voids, % (Compacted Specimen)	---	3.0 - 5.0	3.0 - 5.0	3.0 - 5.0
Stability, (Minimum)	750 lb (3.4 kN)	1000 lb (5.3 kN)	1000 lb (5.3 kN)	1000 lb (5.3 kN)
Flow, 0.01 in (0.25 mm)	8.0 - 20.0	8.0 - 20.0	8.0 - 20.0	8.0 - 20.0
Voids in Mineral Aggregate (VMA)*, % (Minimum)	11.5	13.0	16.0	18.0

* The VMA shall be calculated from the combined bulk specific gravities of the aggregate and the actual asphalt cement content determined by the laboratory testing.

823.22 General Uses for Job Mix Formula Types A, B, C, D, and E.

- Type A - Open plant mix base course
- Type B - Dense graded base and binder course
- Type C - Dense graded surface course
- Type D - Fine, dense graded surface course
- Type E - Curb mix

823.23 Bituminous Concrete Base Course Mixture. Mix and gradation requirements for the base course mixture shall be as follows:

1. Mix Requirements:

Asphalt Content	3.0 - 4.5% of total mixture weight
Air Voids	3.0 - 6.0
Stability	1000 lb. (4.5 kN), minimum
Flow-	8.0 - 18.0 (0.01 in) [0.25 mm]

2. Gradation Requirements:

<i>Sieve Size</i>	<i>Percent Passing</i>
12O (37.5 mm)	100
3/4O (19.0 mm)	75 - 100
3/8O (9.5 mm)	48 - 80
No. 8 (2.36 mm)	20 - 48
No. 30 (600 μm)	10 - 30
No. 50 (300 μm)	7 - 25
No. 200 (75 μm)	3 - 10

During production of the base course mixture, the gradation of the aggregates may vary between the specified limits, but such variations shall be gradual. Sudden variation from coarse to fine and fine to coarse on any sieve will not be tolerated.

823.24 Plant Mix Open-Graded Wearing Surface Mixture. The open-graded wearing surface shall be composed of a mixture of approved aggregate and asphalt cement. Gradation shall be as follows:

<i>Sieve Size</i>	<i>Master Range Percent Passing</i>	<i>Tolerance from Job Mix (%)</i>
2O (12.5 mm)	100	0
3/8O (9.5 mm)	88-98	3
No. 4 (4.75 mm)	25 - 42	5
No. 8 (2.36 mm)	5-15	3
No. 200 (75 μm)	2-5	1.5

Asphalt cement shall be from 6.0 to 8.0% of the total mixture weight (to be determined by Laboratory Tests). The temperature of the asphalt cement shall not be greater than 310 ± 10 °F (154 ± 6 °C) when introduced into the mixer.

A heat-stable, anti-stripping additive conforming to the requirements of Subsection 823.05 shall be added to all asphalt cement used for open-graded surface course. The amount of the additive used shall be between 0.25 and 1.0% by weight of the asphalt cement as recommended by the additive manufacturer and approved by the Department's Materials and Research Section.

The additive shall be thoroughly and uniformly blended with the asphalt cement at the hot-mix production plant in accordance with Subsection 823.16.

The target temperature (" 10 EF) ["6 EC] of the mix leaving the mixer shall be established by the Department on the basis of laboratory tests. A target temperature of 240 " 10 EF (116 " 6 EC) is typical.

Aggregate shall conform to the requirements of [Section 805](#), except slag will not be permitted. The use of limestone or serpentine aggregate or natural sand, washed or unwashed, is prohibited. The use of washed concrete sand is also prohibited.

823.25 Reclaimed Asphalt Pavement (RAP). This material consists of existing asphalt cement concrete pavement material removed by cold milling, or removed and processed such that 100% passes the 10 (25 mm) sieve. If the Contractor has a supply of RAP meeting the approval of the Engineer, a percentage of this material, meeting the requirements of [Subsection 823.26](#) may be substituted for the new materials required to produce bituminous base, binder, or dense surface courses.

The stockpile of RAP shall be free of topsoil, debris, foreign matter, and other contaminants.

823.26 Recycled Asphalt Concrete Mixture. The recycled mixture shall be a blend of RAP, new aggregate, and asphalt cement conforming to the mixture requirements of this Section for the type mix specified. The new aggregate shall conform to the requirements of [Subsections 823.03](#) and [823.04](#). The new asphalt shall conform to the requirements of [Subsection 823.02](#). The percentage of new aggregate is not fixed by this Subsection; however, limitations are placed on the RAP percentage permitted in the recycled mix. A job mix formula must be submitted to the Engineer per [Subsection 823.19](#) and approved prior to initiation of work and for any subsequent changes in the blend of the mixture. The approved ratio of RAP to new aggregate and the percentage of new asphalt cement to be incorporated into the recycled asphalt concrete mixture will be determined by laboratory tests performed on representative samples of stockpiled RAP and new aggregate.

The physical properties of the RAP asphalt cement will be determined by extraction, recovery, and testing. The testing of the physical properties will govern the percentage of RAP permitted in the recycled mix. In all mixture types, the contribution of the RAP asphalt cement shall not exceed 50% of the design asphalt content for the recycled mix.

In addition, the following plant limitations shall apply to all recycled mixtures:

Table 823-A

Maximum Percentage of RAP

<i>Plant Type</i>	<i>Mixtures</i>		
	<i>Deep Lift</i>	<i>Type B</i>	<i>Type C</i>
Dryer-Drum	20	10	10
Batch Plant	20	10	10

Results of single extractions and sieve tests shall not be used as the sole basis for acceptance or rejection of the mixture. Any variation from the job mix formula in the gradation of the aggregate or in the asphalt content that exceeds the tolerances noted below shall be investigated, and the conditions causing the variation shall be corrected.

The following tolerances for the job mix formula will be allowed per single test:

<i>Sieve Size</i>	<i>Percent Passing</i>
20 (12.5 mm) and larger	"8
No. 4 (4.75 mm) and 3/80 (9.5 mm)	"7
No. 100 (150 μ m) to No. 8 (2.36 mm) (inclusive)	"5
No. 200 (75 μ m)	"3
Asphalt content, weight percent of total mixture	"0.4

823.27 Recycled Mix Production. Recycled mixtures may be produced in batch or dryer-drum type plants.

Batch plants shall use the heat transfer method, by introducing the RAP into the plant weigh box at the ambient temperature of the stockpile. With this method, the uncoated, virgin aggregate, shall be superheated in the dryer and transfer its heat to the cold RAP in the plant mixer. A conveying system shall be used to introduce the proper amount of RAP per batch into the weigh box in sequence with the superheated aggregates from the plant hot bins. The mixing cycle shall include a minimum 15-second dry mix cycle prior to introduction of the hot asphalt cement. The mixture produced shall be of uniform, specified temperature, evenly coated, unsegregated, and shall have all the characteristics typical of a virgin aggregate-asphalt mixture for the type mix produced.

Dryer-drum plants used in the production of recycled mixtures shall be specifically designed and equipped by the manufacturer to provide for entrance of the RAP material into the drum with subsequent heating, and for mixing the RAP with the new aggregate and asphalt without direct flame contact, excessive asphalt hardening, or violation of air quality standards. The mixture produced shall be uniform, at the specified temperature, evenly coated, unsegregated, and have all the characteristics typical of a virgin aggregate-asphalt mixture for the type mix produced.

823.28 Use of Recycled Mixtures. Unless prohibited by the Contract, the use of recycled mixtures for the mix types specified by the Contract shall be at the option of the Contractor. All provisions of [Sections 401](#) and [823](#), except as modified in [Subsections 823.25](#), [823.26](#), and [823.27](#), shall govern materials, production, storage, transportation, spreading, finishing, and compaction of recycled materials for the appropriate mix type provided.