

Section 2001. General Equipment Requirements

2001.01 GENERAL.

- A. Obtain Engineer's approval for equipment. Maintain equipment in working condition.
- B. Except as provided in [Article 1105.12, G](#), do not operate equipment that exceeds the legal axle load, as defined herein, on pavement or on primed or unprimed subgrade, subbase, or base course.
- C. Do not use tractors with lugs for manipulating or spreading subbase or base material except when traveling on uncompacted material deposited by spreaders or spreader boxes.
- D. Keep equipment that comes in contact with bituminous materials or bituminous mixtures clean by heating, scraping, or by the use of an approved release agent described in [Materials I.M. 491.15](#). When kerosene, distillates, or other solvents are used, allow the equipment to drain for a minimum of 5 hours after cleaning. Collect the cleaning agents and dispose of according to Federal and State regulations.

2001.02 FIELD LABORATORY.

Comply with requirements of [Section 2520](#).

2001.03 TRUCKS FOR TRANSPORTING BITUMINOUS MIXTURES.

- A. Transport bituminous mixtures using motor trucks with tight metal or metal lined dump bodies. For hot mixes on unusually long hauls or for work after October 1, the Engineer may require the truck bodies to be insulated adequately to retain heat in the mixture.
- B. Transport hot mixes in trucks having a cover of canvas or other suitable material. Covering normally will not be required between May 15 and October 1.

2001.04 MECHANICAL TAMPERS.

- A. In areas inaccessible to rollers where compaction is required and hand tamping is not permitted, use a suitably sized mechanical tamper.
- B. Do not operate pneumatic tampers at pressures lower than the manufacturer's recommendations.

2001.05 ROLLERS.

Use rollers that comply with the restrictions imposed in the specifications for the various types of construction. Use rollers in good repair and designed to do the work required. Use rollers that are approved by the Engineer and comply with the following requirements:

A. Soil Compaction Rollers.

1. Use sheepfoot type rollers consisting of one or more drums having studs or feet projecting no less than 6 1/2 inches (165 mm) from the surface of the drum.
2. Load the roller so that no less than 200 psi (1380 kPa) is exerted on a single row of feet parallel to the axle of the drum.

B. Self Propelled, Smooth, Steel Tired Rollers.

1. Self propelled, smooth, steel tired rollers may be of the 3 wheel type, 2 axle tandem type, or 3 axle tandem type.
2. For natural subgrade, use rollers no less than the 3 ton (2.7 Mg) weight class.
3. For hot asphalt mixtures, use a driving drum no less than 60 inches (1500 mm) in diameter.
4. On tandem type rollers used for hot asphalt mixtures, use a driving drum capable of being filled with liquid ballast. The Engineer may require that it be partially or entirely filled.

5. For all other types of work, use rollers of a weight class no less than 8 tons (7.3 Mg). Load the driving drum to produce a compactive effort not less than 200 pounds per inch (3.5 kg/mm) of width of the roller. When the Engineer requires, weight the steering drum to 200 pounds per inch (3.5 kg/mm) of width of the steering drum.

C. Self Propelled, Pneumatic Tired Rollers.

1. Use tires no smaller than a 7.50 by 15 size.
2. For hot asphalt mixtures, use rollers capable of producing contact pressures of 80 psi (550 kPa). Operate when specified or directed by the Engineer. Ensure the 80 psi (550 kPa) contact pressure is obtainable with a legal axle load.
3. For all other types of work, use rollers loaded to produce a compactive effort no less than 200 pounds per inch (3.5 kg/mm) of width of the roller, based on the maximum ground contact width. Use a tire inflation pressure no less than 60 psi (410 kPa). Rollers complying with the requirements for HMA may also be used.
4. Ensure tire pressures vary no more than 5 psi (35 kPa).
5. Attach an information plate to each roller showing the tire size and ply and the correlation of wheel load and tire pressure with contact pressure. Equip the roller with wheel sprinklers, scrapers, or mats, and during cooler weather, protective skirting around the tires.

D. Pull Type, Pneumatic Tired Rollers.

1. Use tires no smaller than a 7.50 by 15 size.
2. Load the rollers to produce a compactive effort no less than 200 pounds per inch (3.5 kg/mm) of width of the roller, based on the maximum ground contact width.
3. Use a tire inflation pressure no less than 60 psi (410 kPa).

E. Trench Rollers.

1. For trench operations, use trench rollers with a compacting roller of a width no less than 15 inches (380 mm). Equip the rollers with a leveling mechanism to maintain the compacting surface of the roller in the desired plane while compacting surfaces below the edge of the old pavement. If used only to compact the bottom of a trench for widening, the leveling mechanism will not be required, provided the roller is built to fit the slope of the trench bottom.
2. The Engineer may require the roller loaded to produce the compactive effort best adapted to the work, to a maximum of 250 pounds per inch (4.5 kg/mm) of width of the tire.
3. Operate pneumatic tired rollers at an inflation pressure no less than 60 psi (410 kPa).

F. Self Propelled Vibratory Rollers.

1. Use self propelled vibratory rollers suitable for the use intended. The manufacturer's handbook shall be available to the operator.
2. Control the speed of the roller so there is a minimum of 10 impacts per linear foot (35 impacts per meter).
3. The Engineer will consider other types of rollers for approval.

2001.06 MATERIAL BINS.

- A. For the purpose of this article, the word "bin" is defined as any structure in which materials are stored. The requirements apply to any bin that an inspector, while performing sampling or inspection duties, might work upon or beneath.

- B. Ensure each part of each bin, including foundations and connections, has adequate strength to withstand any stress to which it might be subjected while in use.
- C. The Engineer may inspect each portable bin each time it is erected. The Engineer may reject the use of any bin that does not perform as intended, or otherwise exhibits any unsafe condition.

2001.07 WEIGHING EQUIPMENT AND PROCEDURES.

This article describes equipment capability and procedures to be used when payment for an item is based on weight (mass).

A. Weighing Equipment.

1. Use weighing equipment meeting the requirements of the Iowa Department of Agriculture for measuring pay items. Ensure truck weighing equipment is of sufficient length to weigh, at one time, the maximum truck and trailer combination, or situate separate equipment so that both truck and trailer can be weighed at the same time. Make available upon request, at least 10 standard 50 pound (22.68 kg) test weights and suitable cradles and platforms for the purpose of testing weighing equipment.
2. Ensure weighing equipment is:
 - Accurate to 2 pounds per 1000 pounds of weight (2 kg per 1000 kg), and
 - Sensitive to a weight (mass) equal to 0.1% of the quantity being weighed but no less than 20 pounds (9 kg) and no less than a weight (mass) equal to one of the minimum graduations on a beam or dial scale.
3. When electronic devices such as load cells, computers, and printers are a part of the weighing equipment, ensure they are sealed or otherwise protected to prevent any unauthorized adjustment. Weighing systems which have been tampered with may be rejected from further use until the system has been checked and/or recalibrated. Furnish a copy of the manufacturer's detailed step by step instructions for adjusting and/or checking for accuracy, sensitivity, and tolerance of the equipment.
4. Tare all trucks to be weighed before loading. Tare these trucks daily thereafter, preferably on a random time basis. Use the previous day's tare until a new tare is determined.
5. Provide a scale ticket to the Engineer with each load. Also, provide a scale ticket when tares are determined for verification and check weighing. "Verification weighing" is a second weighing of the same load on the same equipment. "Check weighing" is a second weighing of the same load on different weighing equipment. Perform check weighing on a certified truck scale. Ensure scale tickets, as a minimum, identify project number, date, truck number, type of material, and total net weight (mass).
6. Except for automatic weighing, use a weighmaster, as defined in Chapter 214, Code of Iowa, to weigh all loads or load increments. Ensure the weighmaster, or operator for automatic weighing, signs the first scale ticket of each day and initials all subsequent tickets, or prints them using automatic equipment.
7. Check weighing and verification weighing may be made at any time as directed by the Engineer. The Engineer may check the operation of the equipment at any time. The verification weight (mass) shall not be different from the initial weight (mass) by more than 0.1%. When check weighing on a platform scale, the check weight (mass) shall not be different from the initial weight (mass) by more than 0.3%.
8. When the material is not weighed in the truck, (for example, weighing in a weigh hopper or determining weight from initial and final weighing of a weigh silo) perform check weighing on a certified truck scale. The net check weight (mass) shall not be different from the initial net weight (mass) by more than 100 pounds (45 kg). A suitable fuel adjustment may be made.
9. If the weight (mass) is not within the tolerances stated above, the Engineer may adjust the weight (mass) of loads previously weighed on the weighing equipment that day, and the previous day, by the difference greater than the specified tolerance. Perform verification and check weighings at no additional cost to the Contracting Authority.

B. Special Procedures for Asphalt Mixtures, Aggregates, and Binders.

1. Use automatic or semi automatic weighing on projects with:
 - Contract quantities of asphalt mixtures totaling 10,000 tons (10,000 Mg) or more, or
 - Aggregates totaling 10,000 tons (10,000 Mg) or more from a single source.
- a. **Automatic Weighing.**
Use weighing equipment that is self balancing and includes an automatic weight (mass) recorder. Have all tickets printed automatically with net weight (mass) and all weights (mass) needed to determine total net weight (mass).
- b. **Semi Automatic Weighing.**
 - 1) The weighing equipment may be self balancing or manually balanced. Use equipment that includes an automatic weight (mass) recorder that:
 - Will not print until the equipment is balanced, and
 - Prints the gross weight (mass) or the batch weights (mass) and number of batches.
 - 2) For weigh hoppers, ensure the printout includes the empty weight (mass) after each discharge.
2. For measurement of asphalt binders by tank stick or in-line flow meter, meet the requirements of [Materials I.M. 509](#) for calibration and measurement.
3. For asphalt mixtures, provide daily totals to the Engineer for all mixture quantities produced and used in the project. Provide daily totals to the Engineer for all mixture quantities produced and not incorporated into the project. Ensure this total identifies the quantity of asphalt binder used, but not incorporated.

2001.08 EQUIPMENT FOR PREWETTING AGGREGATES AND AGGREGATE MIXTURES.

Use equipment complying with one of the following:

A. Standard Mixer.

Use equipment that provides accurate control of the proportions of water and aggregate, as well as positive, thorough mixing of the materials. Dow boxes will be approved as a Standard Mixer.

B. Pugmill Mixer.

1. When this equipment is specified, ensure it:
 - Provides accurate control of the proportions of water and aggregate, and
 - Is designed so that the material can be retained in the mixing chamber under vigorous mixing action for at least 15 seconds.
2. If using continuous flow type mixers, use ones that:
 - Have twin mixing shafts, and
 - Are equipped with a hopper or bin at the discharge end of the mixer designed to minimize segregation of the mixed materials.

2001.09 WATER DISTRIBUTORS.

- A. To apply water to the roadway, use a distributor mounted on a truck or trailer equipped with pneumatic tires.
- B. Use a distributor equipped with an adequate pressure pump and spray bars to distribute water evenly over the intended area.
- C. Use distributors that have a:
 - Spray bar with correct size and pattern of nozzles,
 - Means to maintain uniform nozzle pressure,
 - Means to control application rates between 0.05 to 0.50 gallon per square yard (0.20 to 2.50 L/m²), and
 - Positive sprayer shutoff mechanism.

- D. For trench operations, use distributors that have an offset spray bar with replaceable nozzles so the width to which water is applied can be adjusted to the work.

2001.10 WATER SUPPLY EQUIPMENT.

- A. Use water supply equipment, including pipe lines and water trucks, of a capacity and nature to ensure an ample supply and sufficient pressure for all the requirements of the work.
- B. When pumping is necessary, backup pumping equipment may be required.

2001.11 EQUIPMENT FOR HEATING BITUMINOUS MATERIALS.

- A. Use equipment for heating bituminous material that:
 - Has adequate capacity to heat the material to the temperatures specified,
 - Is equipped with an accurate thermometer which will indicate the temperature of the bituminous material in the unit in which heat is being applied,
 - Will not damage the bituminous material by local overheating or by contamination with the material used for the transfer of heat, and
 - Will ensure continuous circulation between the storage tank and the mixer during the operating period.
- B. Heat the material under control by:
 - Using circulating steam or a liquid through coils in the car or tank,
 - Electric heat,
 - Circulating the bituminous material through a separate heating unit, or
 - Other means so that no flame is applied to metal with which the bituminous material comes in contact.
- C. Jacket or insulate all pipe lines to prevent heat loss.

2001.12 EQUIPMENT FOR DISTRIBUTING BITUMEN.

- A. Mount distributors on motor trucks or trailers. Ensure distributors comply with the restrictions imposed in the specifications for the various types of construction. Use only those distributors which are in good repair and are designed to do the work. Use distributors and trucks that are approved by the Engineer.
- B. Equip distributors with adequately sized burners and flues for heating the bituminous material. Ensure they have a means for circulating the material in the tank when the burners are in operation. Equip distributors with adequate and safe catwalks or ladders for use in making stick measurements.
- C. Equip each unit with the following:
 1. An accurate thermometer for indicating the temperature of the bitumen in the tank.
 2. A tachometer operated by a wheel independent of the truck wheels.
 3. A calibrated or verified measuring stick.
 4. A quick opening gate in the dome of the distributor tank.
 5. Quick cutoff valves at the nozzles or other means for reversing the direction of flow through the nozzles.
- D. Use separate power supplies for the pressure pump and the distributor drive train. Pressure equipment which depends on the drive train power for the distributor may be approved provided special devices are installed to ensure that variation from the designated rates of application will not exceed 0.02 gallon per square yard (0.10 L/m²). Use a pressure system with sufficient capacity to produce a uniform, fine, even spray from all the nozzles for the maximum width of the spray bar used. Ensure it is capable of distributing bitumen at rates varying from 0.03 to 0.50 gallon per

square yard (0.15 to 2.50 L/m²). Use nozzles of a size such that bitumen may be spread in a uniform coating without the forward speed exceeding 20 mph (30 km/h).

- E. Use spray bars that are adjustable for the widths of application required by the work. Equip them with a means of shifting at least 6 inches (150 mm) laterally from the center position during bitumen application. Use spray bars that are also adjustable vertically to ensure uniform transverse application of the bitumen. Equip distributors used for applying bituminous seal coat binder bitumen with a positive means for maintaining a constant nozzle height (within $\pm 1/2$ inch (15 mm)) during discharge of the load. If dollies are used for maintaining the constant nozzle height, use a spray bar mounting that adjusts vertically.
- F. With each distributor, provide the manufacturer's instructions for use, including specific recommendations for the following:
 - 1. Spray bar height above road surface.
 - 2. Nozzle size and angle of spray fan with spray bar axis.
 - 3. Tables showing rates of distribution in gallons per square yard (liters per square meter) for tachometer readings, spray bar pressure, or pump revolutions, and for various widths of spray bars.
- G. Calibrate or verify the tanks of all distributors that have not been previously checked:
 - Before being initially used, and
 - After any damage or alteration which may affect the calibration.
- H. Calibrate distributors initially at the Iowa DOT Materials Laboratory. Verification of a manufacturer's calibration may be made by the Iowa DOT Materials Laboratory or by a District Materials Office. Have distributor calibrations certified annually by either the Iowa DOT Materials Laboratory or District materials personnel. If distributors are found to have inaccurate calibrations, have distributors recalibrated by the Iowa DOT Materials Laboratory before further use.

2001.13 SPREADERS.

This article applies to equipment used for distribution of certain materials, other than liquids, where it is required that the material be distributed on a roadbed at a specified uniform rate.

A. Non-Self-Propelled Cover Aggregate Spreaders.

Comply with the following:

- 1. Equipped with a mechanical feed of a length at least equal to the width to which aggregate is spread with a single pass of the spreader.
- 2. Capable of depositing aggregate from the transporting vehicle directly upon freshly applied bitumen in a smooth, uniform layer, at the rate required and in a manner that equipment will not come in contact with the bitumen until the bitumen is covered with a layer of aggregate.
- 3. Equipped so that they may be filled and moved without discharging aggregate.

B. Self-Propelled Cover Aggregate Spreaders.

Comply with the requirements of [Article 2001.13, A](#), and the following:

- 1. Are mounted on pneumatic tires.
- 2. Have a width of spread no less than 13 feet (3.9 m).
- 3. Provide cutoff plates to permit the width of spread to be reduced in increments of 1 foot (0.3 m) from the maximum to 4 feet (1.2 m).
- 4. Are capable of spreading aggregate of 1 inch (25 mm) maximum size at any rate desired from 3 to 50 pounds per square yard (1.5 to 27 kg/m²) of surface covered.

5. Provide a hopper with the following qualifications (conveyers are suitable for conveying the aggregate from the hopper to the spreading element):
 - a. Has a capacity of no less than 5 tons (4.5 Mg).
 - b. Is integral with the spreader unit.
 - c. Can receive aggregate from transporting vehicles without the wheels of such vehicles coming in contact with uncovered bitumen on the road surface.
 - d. Augers or agitators distribute aggregate uniformly to the spreading element without segregating aggregate particles.
6. Have adequate power to propel the spreader at uniform speed on gradients up to 6%.

C. Sand Spreader.

For spreading sand cover for tack and seal coat, use a spreader that has one (or more) horizontal rotating disk fed by a conveyor and driven by power takeoff or by a separate unit.

D. Materials Spreader for Base Widening Work.

1. Place the material used in base widening by machine without dumping on the pavement.
2. Use a machine that will spread the base materials in a uniform layer of the desired thickness and width in a uniformly loose condition.
3. Locate the wheels of the spreader so they do not operate on the 1 foot (0.3 m) width of pavement adjacent to the edge of the base widening.

2001.14 BROOMS.

Use a rotary type broom driven by an auxiliary motor or by a power takeoff from the power plant of the unit propelling the broom.

2001.15 MOTOR GRADERS.

Equip motor graders used in trimming edges of subbases or bases with an offset blade with supplementary cutting edge designed so the wheels of the motor grader will be operated entirely on the surface of the base or subbase.

2001.16 SCARIFYING EQUIPMENT.

Use scarifying equipment designed and operated to loosen the material to the depth specified.

2001.17 PULVERIZING EQUIPMENT.

Use pulverizing equipment designed and operated to pulverize the material to the degree specified.

2001.18 TRENCH EXCAVATING MACHINES.

- A. Use a machine designed for the required purpose.
- B. Use equipment capable of excavating the material to the full, normal design depth and suitable width.

2001.19 ASPHALT MIXTURE PAVING MACHINE.

- A. Spread all asphalt mixtures to be placed 8 feet (2.4 m) wide or more in width using a self-propelled finishing machine which will receive the hot mixture and spread the mixture in a layer of uniform density to the desired thickness.
- B. Use a finishing machine consisting of a tractor unit and a screed unit.
 1. Use a tractor unit with dual controls to permit operation of the finishing machine from either side. The tractor unit will provide the motive power and may be mounted on crawler treads or pneumatic tires. If mounted on pneumatic tires, maintain sufficient inflation pressure to keep vertical movement to a minimum. Ensure the length of crawler treads or distance between axles, if mounted on pneumatic tires, is sufficient to allow the tractor unit to pass over small irregularities in the base without abrupt vertical movement.

2. Attach the screed unit to the tractor unit so that it is free floating on the mixtures being placed. Equip the screed with vibrators or tampers for giving the initial consolidation to the material. Operate this equipment at the frequency the manufacturer recommends. Ensure the screed unit operation produces a smooth surface, free from surface tears or voids, and within the permissible variation specified for the type of work involved.
 3. Use a screed unit that is adjustable to the crown of the finished surface. Ensure it is equipped with an approved device which will indicate the slope of crown. Provide a minimum 2 foot (0.6 m) long straightedge for checking the installation of screed extensions.
 4. A screed extension may be used, provided it has a screed plate with vibration. If the extension exceeds 1 foot (0.3 m), extend the auger as well. Other extensions will be allowed only for use in placing fillets or short or irregular tapers.
- C.** Do not use finishing machines which operate with rollers on the freshly placed mixture.
- D.** Unless otherwise specified, use a finishing machine that has automatic screed controls, except for the following uses:
1. Wedge courses.
 2. Curb fill resurfacing.
 3. Urban type sections containing fixtures or other permanent grade control features.
 4. Surface layers 1 inch (25 mm) or less in thickness.
 5. Special leveling course (scratch course) in which the screed rests entirely on the high spots of the underlying base during the paving procedure.
 6. Single course resurfacing on Secondary projects.
- E.** Ensure automatic controls:
1. Have grade and slope control systems which operate with an approved grade reference system.
 2. Work in conjunction with a ski type device, traveling stringline, or other approved, self contained grade referencing system.
- F.** Use a self contained grade referencing system no less than 30 feet (9 m) long. Verify both the grade and slope controls are adequately sensitive and in proper working order at all times. During malfunctions the Engineer may permit the completion of the day's work using manual controls.
- G.** A special commercial joint matching shoe may be used when constructing longitudinal joints on surface courses:
- When placing a single lift only, with a thickness of 1 1/2 inches (40 mm) or less, or
 - For placement in conjunction with heater scarification work.
- H.** For placing the final lift of paved shoulders, use finishing machines or pavement widening machines that have an automatic grade and slope control system approved by the Engineer. The joint matching shoe may be used when placing any paved shoulder.
- I.** Obtain the Engineer's approval for machines used for spreading mixtures on areas less than 8 feet (2.4 m) wide. Do not use machines which are less than standard size for highway work without the Engineer's permission.
- J.** Obtain the Engineer's approval for use of material transfer vehicles. The Engineer will base approval on bridge and pavement structural evaluation of resultant axle and wheel loads.
- K.** When using a windrow pick-up process, control the process to produce a windrow that is uniform and does not extend more than two truck dumps ahead of the paver. Pick up all hot mix material

from the windrow and deposit it in the paver. Balance windrow placement to maintain a uniform quantity of material in the paver hopper.

2001.20 EQUIPMENT FOR WEIGHING AND PROPORTIONING PORTLAND CEMENT CONCRETE MATERIALS.

A. General.

1. Use weighing and proportioning equipment that meets the requirements of this article. Allow the Engineer every opportunity to witness calibration of the equipment during the Engineer's normal working hours, or at a mutually agreeable time. This schedule limitation will be modified, if necessary, for work to be done according to an accelerated work schedule. The Engineer may consider a report concerning equipment and its calibration certified by a Professional Engineer licensed in the State of Iowa in lieu of this calibration. The Engineer may, at any time, perform such tests or checks as necessary to verify a report or to assure continued compliance.
2. Coarse aggregate sampling facilities which permit collecting representative portions of a ribbon or stream will be required at the proportioning plant site. The Engineer will designate a sampling point:
 - Prior to individual material identity loss in the proportioning mixing process, and
 - After delivery to the plant or after delivery to a site stockpile, whichever is nearest the mixer.
3. Furnish personnel, test weights, and equipment for calibration of the plant and for verifying accuracy of proportions. Arrange for weighing water to calibrate the water meter.

B. Proportioning Equipment.

1. Use proportioning equipment complying with the following requirements:
 - a. Accurate to 0.5% of the batch weight (mass).
 - b. Sufficiently sensitive so that 0.1% of the batch weight (mass) or 2 pounds (1 kilogram), whichever is greater, will be detectable.
 - c. Weighs each individual material within $\pm 1.0\%$ of the batch weight (mass) and returns to zero within $\pm 0.5\%$ of the batch weight (mass).
 - d. Is protected from air currents, vibration, and so forth which may affect the accuracy of weighing. Keep all fulcrums, clevises, and similar working parts clean and in proper working condition.
 - e. Has available upon request, at the plant site, standard test weights for calibrating weight equipment according to Table 2001.20-1. Have suitable devices available for conveniently applying test loads.

Table 2001.20-1: Standard Test Weights

Nominal Scale Capacity lb (kg)	Minimum Test Weights (Mass) Required Total lb (kg)
0 to 500 (0 to 225)	2 @ 50 lbs. ea. (2 @ 22.68 kg ea.)
Over 500 to 5000 (Over 225 to 2250)	500 (225)
Over 5000 to 10,000 (Over 2250 to 4500)	1000 (450)
Over 10,000 (Over 4500)	2000 (900)

- f. Weighs cement in an independent hopper.
 - 1) Use a weigh hopper that has:
 - a) A dust tight seal between the charging mechanism and the batching hopper which will not affect the accuracy of weighing.
 - b) A discharge hose or device which will prevent the loss of cement during discharge.
 - 2) Do not allow any part of the discharge device which comes in contact with the receiving equipment to be supported by the weigh hopper. Ensure cement hoppers

are equipped with a vibrator and with a vent which will adequately release air pressure which may affect weighing.

- g. Will weigh fly ash and GGBFS according to the requirements of weighing cement. Fly ash and GGBFS may be weighed in the same hopper as the cement, provided the cement is introduced into and weighed in the hopper first.
 - h. Sets and operates automatic weighing equipment, if used, with the following interlocks:
 - 1) The charging mechanism cannot be opened until the equipment has returned to zero balance within $\pm 0.5\%$ of the batch weight (mass).
 - 2) The charging mechanism cannot be opened if the discharge mechanism is open.
 - 3) The discharge mechanism cannot be opened if the amount in the hopper is over or under by more than 1.0% of the batch weight (mass).
2. When automatic weighing equipment is required:
- a. Manual controls may be used for emergencies. Manual controls will not be permitted longer than 1 working day after automatic batching equipment failure.
 - b. Weigh fly ash according to the requirements for cement.

C. Water Measuring Equipment.

- 1. Measure water using equipment that will clearly indicate the volume or weight (mass) being measured with an accuracy of 2 pounds (1 kg) or $\pm 1.0\%$, whichever is greater. Arrange the equipment so the accuracy of the measurement will not be affected by variations in pressure of the water supply line. Unless water is measured by weight (mass), provide containers in which the entire quantity of water required for one batch of concrete may be weighed for calibration purposes.
- 2. Equipment that measures moisture in the fine aggregate and adjusts the batch amounts of fine aggregate and batch water on a continuous basis will be allowed provided satisfactory calibration and correlation procedures are met.

D. Equipment for Admixtures.

- 1. Use equipment for dispensing liquid admixtures that is accurate within $\pm 3.0\%$ of the quantity required. The visual inspecting chamber requirement may be waived in lieu of admixture dispensing systems using positive electronic flow metering and computer controlled delivery that prevents improper admixture incorporation into the mix. Ensure dispensing equipment has a means for routine diversion of a measured quantity into a suitable vessel for calibration and for periodic verification of the batch quantity.
- 2. When liquid admixtures are proportioned and introduced into the mix, use equipment and procedures that meet the following requirements:
 - a. Measures and automatically introduces separately each individual admixture into the mixer with the mixing water.
 - b. Uses a dispenser equipped with a measuring chamber which provides a means of determining the batch quantity by visual inspection.

E. Equipment for Volumetric Proportioning.

- 1. Use volumetric proportioning equipment meeting the applicable requirements of ASTM C 685, Sections 5, 6, 7, and 8 and the applicable requirements of [Article 2413.03, A, 3](#).
- 2. Calibrate each time, when in the Engineer's opinion, material or condition changes may affect the calibration.
- 3. It is not intended that this equipment be used in place of conventional drum mixing equipment normally used for structures and paving applications.
- 4. This equipment may be used on miscellaneous pours, described in [Materials I. M. 534](#), less than 50 cubic yards (50 cubic meters) per day.
- 5. Equipment used on miscellaneous pours shall be equipped with a batch ticket printer to include the cement, coarse and fine aggregate, and water count. Equipment used in

accordance with [Section 2413](#) shall be equipped with a batch ticket printer for the cement count.

2001.21 PORTLAND CEMENT CONCRETE MIXING EQUIPMENT.

A. General.

1. Use mixing equipment that meets the requirements of this article for the type specified.
2. Allow the Engineer every opportunity to witness the calibration of the equipment during the Engineer's normal working hours, or at a mutually agreeable time. This schedule limitation will be modified, if necessary, for work to be done under an accelerated work schedule.

B. Construction or Stationary Mixer.

1. Use only batch type mixers.
2. Do not allow the total volume of the batch to exceed the designated size of the mixer or the rated capacity as shown on the manufacturer's rating plate.
3. After all solid materials are assembled in the drum, mix for a minimum of 60 seconds and a maximum of 5 minutes. The Engineer may increase the mixing if the mixer efficiency tests show that the concrete is not satisfactory for uniformity or strength. Use an accurate timing device that:
 - a. Indicates minimum mixing time.
 - b. Starts automatically when the mixer is fully charged.
 - c. When applicable, locks the discharge chute until the expiration of the required time.
4. Operate mixers at the manufacturer's recommended mixing speed. Charge the batch into the mixer so that:
 - Some water will enter in advance of cement and aggregates, and
 - All water is in the mixing chamber by the end of the first 25% of the specified mixing time.
5. Operate mixing drums of tilting drum mixers at an angle no steeper than the mixer manufacturer's recommendation. Do not use a mixer if the drum is not clean or if the mixing blades are damaged or badly worn.
6. When a construction or stationary mixer is used for mixing pavement concrete, have the quantities of fine aggregate, coarse aggregate, cement, mineral admixture, liquid admixture and water for each batch automatically documented on individual batch tickets or on a daily summary. Have the time of discharge for each batch recorded automatically as well. These proportioning documents will become property of the Contracting Authority.

C. Truck Mixer and Agitator.

1. The equipment shall have a metal plate or plates attached with the following information:
 - Gross volume of the drum
 - Mixed concrete capacity
 - Maximum and minimum mixing speed

The plate may be issued by the Truck Mixer Manufacturers Bureau, if not, have an independent laboratory meeting the requirements of ASTM C 1077 perform the proof tests described in Annex A1 of ASTM C 94. The test report of the proof test results may be required.

2. Do not exceed mixer or agitator capacity. Keep mixing and agitator speeds within the designated limits. Equip truck mixers with reliable reset revolution counters. If truck mixers are used for mixing while in transit, the revolution counter is to register the number of revolutions at mixing speed.
3. Have an authorized representative of the concrete producer certify that:
 - a. The interior of the mixer drum is clean and free of hardened concrete,

- b. The fins or paddles are not broken or worn excessively,
 - c. The other parts are in proper working order,
 - d. The unit has been checked by the representative within the previous 30 calendar day period to substantiate this certification.
4. Keep the current, signed certification with the unit at all times.
 5. For bridge floor concrete, ensure mixing is between 70 and 90 revolutions. For other structural concrete and pavement concrete, ensure mixing is between 60 and 90 revolutions with satisfactory preblending of the materials, or between 70 and 90 revolutions without preblending. Use the manufacturer's designated mixing rate. Keep the mixing rate duration between the limits stated above to produce uniform, thoroughly mixed concrete.
 6. The Engineer may inspect mixer units at any time to assure compliance with certification requirements. Removal of inspection ports may be required. Should the Engineer question the quality of mixing, the Engineer may check the slump variation within the batch. Should the slump variation between two samples taken, one after approximately 20% discharge and one after approximately 90% discharge of the batch, show a variation greater than 3/4 inch (20 mm) or 25% of the average of the two, whichever is greater, the Engineer may require:
 - The mixing to be increased,
 - The batch size reduced, or
 - The unit removed from the work.

D. Continuous Mixer.

A continuous mixer used in conjunction with volumetric proportioning may be approved as provided in [Article 2001.20, E](#).

2001.22 PLANT EQUIPMENT FOR HOT MIX ASPHALT MIXTURES.

Ensure plant equipment will proportion each aggregate, dry and heat the aggregate (except mineral filler), proportion the aggregate and hot asphalt, and mix all materials. The plant may be of a batch type, continuous type, or drum mixing type. Ensure the plant is equipped to produce uniform mixtures of required composition, heated to the desired temperature.

A. Aggregate Feeders for Dryer Drum or Drum Mixer.

1. Ensure the following:
 - a. The feeder uses mechanical means to accurately feed each aggregate (except for mineral filler added without heating) to a central elevator or conveyor in the proportion prescribed by the approved design mix.
 - b. The feeders are belt type feeders equipped with adjustable gates or adjustable drive systems that can be calibrated and controlled.
 - c. The feeder throats are of sufficient size to ensure positive and continuous flow.
 - d. All feeders mechanically or electronically interlocked during operation.
 - e. On some types of feeders, revolution counters capable of registering to a tenth of a revolution may be necessary (and may be required) for accurate calibration and control.
2. When drum mixing plants are used, ensure:
 - a. The central conveyor is equipped with a continuous weighing system with a recorder that can be monitored by the plant operator.
 - b. The aggregate weighing system interlocks with the asphalt control unit.
3. If a drum mixing plant is adding RAP, ensure the following:
 - a. A dual weigh belt system is used to control delivery of virgin aggregates and recycled material to the dryer.
 - b. The belt system is equipped with interlocking control mechanisms in a manner that will assure positive and accurate delivery of recycled and virgin materials in proper proportions at all times.
 - c. The belt system includes recorders that will record the total amount of material being delivered by each belt system separately.
 - d. The belt weighing controls are connected to a totalizer which is interlocked with the asphalt delivery system in a manner which will ensure that asphalt delivered to the mix is

at all times within $\pm 0.3\%$ of the intended amount. Obtain the Engineer's approval for the system.

- e. The Engineer is provided a schematic diagram of the control system prior to plant calibration.

B. Dryer Drum and Drum Mixer.

Ensure the following:

1. The plant is equipped with means for drying and heating the aggregate and/or mixture.
2. Heating is controlled to avoid damage to the aggregate and asphalt.
3. Operation of the equipment is controlled so the specified temperature is maintained.

C. Screens.

Ensure the plant is equipped with adequate means to remove objectionable oversize and foreign material from the aggregate before entering into the hot aggregate bin dryer drum, or drum mixer.

D. Aggregate Bins.

Ensure the following:

1. The plant has aggregate bins of sufficient capacity to ensure uniform and continuous operation.
2. The heated aggregate storage is provided with sufficient ventilation by means of a stack or connection to the dust collection system so that moisture from the hot aggregate will be removed before condensing in the aggregate storage.
3. When mineral filler is added without heating, adequate additional dry storage is provided for the mineral filler, and provisions are made for proportioning the filler uniformly in the desired proportion for the mixture.

E. Equipment for Heating and Storing Asphalt Binder.

Apply [Article 2001.11](#) for heating asphalt binder. Comply with the following:

1. Provide duplicate storage facilities of sufficient capacity to permit complete unloading of a tank car or truck transport in a single operation, unless the asphalt binder is supplied to the project from transports measured by weight (mass).
2. Fill and withdraw storage material from each tank as a separate, definite operation which will permit the Engineer to measure the quantity of asphalt binder used from each storage tank.
3. Install and maintain each storage tank in a level position.
4. Furnish measurement devices and gauging tables so accurate determinations of quantities used and stored can be made at regular intervals.
5. Provide suitable means for maintaining the specified temperature of the asphalt binder in the pipe lines, meters, weighing buckets, spray bars, and other containers and flow lines.
6. Include a spigot for removing asphalt samples from the delivery line to the mixer before the asphalt binder is metered into the mixer or weighed.

F. Asphalt Binder Control Unit.

Provide satisfactory means, by weighing, metering, or volumetric measurements, to add the proper amount of asphalt binder to the aggregate. Operate all measuring devices within a delivery tolerance of 1.5% by weight of binder.

1. Batch Plants.

- a. Measure the quantity of asphalt binder for each batch on equipment meeting the appropriate requirements of [Article 2001.07, A](#), or by an approved automatic batch metering system.
- b. When used for proportioning only, meet the appropriate equipment requirements of [Article 2001.20](#).
- c. Use a sufficiently flexible means of heating that will not affect the weighing.
- d. Arrange the container so that it will deliver the asphalt binder in a thin, uniform sheet or in multiple streams the full width of the mixer, except in the case of a mixer into which the asphalt binder is sprayed. If the binder is deposited on a flow or spreader sheet, use a heated sheet with sufficient slope to discharge promptly into the mixer.

2. Continuous Plants.

- a. Comply with the following:
 - 1) To supply asphalt binder to the mixer, use a pump constructed to be under a positive pressure sufficient to maintain uniform delivery from the pump. The pressure is to be maintained within ± 0.5 psi (5 kPa) of the recommended operating pressure.
 - 2) Install accurate pressure gauges in readily accessible locations in lines feeding the metering pump and the mixer spray bars. Install gauges of such size that the normal operating pressure can be easily read to the nearest 1.0 psi (10 kPa).
- b. For the mixer unit, comply with the following:
 - 1) Equip with a surge tank or a deaeration chamber for supplying a constant pressure flow of asphalt binder to the metering pump.
 - 2) The surge tank or the deaeration chamber is to be of dimensions and capacity to provide the pressure specified. The capacity is to be at least a 6 minute supply of asphalt binder at the normal mixing rate of the mixer unit.
 - 3) The surge tank or the deaeration chamber is to be fitted with baffles and other appurtenances necessary to prevent the incorporation of air bubbles into the asphalt binder as the tank is being filled.
 - 4) When the surge tank system is used, the pressure at the spray bar is to be no greater than 20 psi (140 kPa).
 - 5) When a deaeration chamber system is used, the pressure difference between the return line and the spray bar is to be no greater than 20 psi (140 kPa).
 - 6) Separate return lines are to be provided for each tank.
 - 7) Obtain the Engineer's approval for the surge tank or the deaeration chamber.

3. Drum Mixing Plants.

Ensure the following:

- a. The plant uses a pump to supply asphalt binder to the mixer, which is constructed to be under positive pressure sufficient to maintain uniform delivery from the pump.
- b. A totalizing flow meter is placed in the line between the metering pump and mixer unit.
- c. The asphalt control unit is interlocked with the aggregate weighing system specified in [Article 2001.22, A](#), and is equipped to automatically adjust for variation in aggregate delivery.
- d. The plant is operated with automatic controls, except when approved by the Engineer.
- e. The asphalt control unit is equipped so the plant operator can monitor and adjust the flow rate of aggregate or asphalt binder.

G. Thermometer Equipment.

Install an accurate, registering pyrometer or other approved thermometric instrument in the discharge chute of the dryer drum or drum mixer in a manner so the temperature of the heated aggregate or mixture is continuously measured. Locate this instrument where it is in clear view of the plant or dryer operator and readily accessible to the Engineer.

H. Control of Mixer Capacity and Mixing Time.

Equip the plant with positive means to govern and maintain mixing time.

I. Dust Collector.

- 1. Install and properly maintain proper housings, mixer covers, and dust collecting systems and returns.

2. Obtain the Engineer's approval for the method of returning dust collected by dry type collection systems to the hot aggregate mixture. If not required in the mixture, remove the bag house fines from the project and plant site.
3. When wet type collection systems are used, remove all wet material from the project and plant site.

J. Hot Aggregate Proportioning.

Apply the requirements of this article only to batch plants.

1. Accurately weigh the mineral filler and dried aggregate from each bin in a weighing hopper that is of ample size to hold a full batch without hand raking or running over.
2. Support the weighing hopper so it will not be easily thrown out of alignment or adjustment.
3. Construct gates on bins and hoppers to prevent leakage when closed.
4. Separately proportion mineral filler which is added cold from a hopper and feed uniformly into the heated aggregate before delivery to the pugmill.
5. Weigh the quantity of aggregate for each batch on equipment meeting the appropriate requirements of [Article 2001.07, A](#). When this equipment is used for proportioning only, meet the appropriate requirements of [Article 2001.20](#).

K. Mixer.

1. Batch Mixer.

- a. Use twin shaft pugmills capable of producing a uniform mixture within the job mix or other specified limits.
- b. Do not exceed 3/4 inch (20 mm) clearance of the blades from all fixed and moving parts. Orient the blades according to the manufacturer's recommendation.
- c. If the pugmill is not enclosed, equip it with a dust hood to prevent loss of dust by dispersion.
- d. Construct the mixer to prevent leakage of contents until the batch is to be discharged.
- e. Use an accurate time lock to control the operation of a complete mixing cycle by:
 - 1) Locking the weighing hopper gate when the mixer is charged and until the mixer gate is closed at the completion of the cycle.
 - 2) Locking the outlet of the asphalt binder delivery system throughout the dry mixing period.
 - 3) Locking the mixer gate throughout the dry and wet mixing periods.
- f. The dry mixing period is the interval of time between the opening of the weighing hopper gate and the application of asphalt binder. The wet mixing period is the interval of time between the application of asphalt binder and the opening of the mixer gate. Ensure control of the timing is flexible and capable of being set at intervals of no more than 5 seconds. Install a mechanical batch counter as part of the timing device and design it to register only completely mixed batches.
- g. When adding RAP:
 - 1) Modify batch plant equipment to provide for accurate proportioning of the recycled material and for adding it directly into the weigh hopper, with weighing as a separate increment of the total batch.
 - 2) The RAP may be added to the hot elevator with no preheating. In any method where preheating is being done, the equipment must be specifically designed for this purpose.
 - 3) For RAP proportioning systems, meet the requirements of [Article 2001.22, A](#).
 - 4) When the heat transfer method is used, superheat the new aggregate so that, when combined with the RAP, the temperature of the resultant mixture will meet all requirements for mixing and placing the hot mixture.
 - 5) Obtain the Engineer's approval for each plant modified for recycling mixtures.
 - 6) For each job mix formula within a project, provide daily printouts identifying weight of RAP separately from total batch as recorded by a totalizer.

2. Continuous Mixer.

- a. Use an approved twin shaft pugmill capable of producing uniform mixtures within the job mix or other specified limits.
- b. Ensure paddles are of a type adjustable for angular position on the shafts and reversible to retard the flow of mix.
- c. Equip the mixer with a discharge hopper holding approximately 1 ton (1 Mg) and discharging intermittently by means of quick acting gates.
- d. Regulate the distance to the receiving vehicle to minimize segregation.
- e. Provide satisfactory means to afford positive interlocking control between the flow of aggregate from the bins and the flow of asphalt binder from the meter or other proportioning source. Accomplish control by interlocking mechanical means or by any positive method for accurate control.
- f. Include an accurate revolution counter, operating continuously during production.
- g. Equip the plant with positive means to govern and maintain a constant time of mixing.

3. Drum Mixer.

- a. Comply with the following:
 - 1) Use equipment capable of producing uniform mixtures within the job mix or other specified limits.
 - 2) Introduce the aggregate, asphalt binder, and additives, when furnished, continuously and uniformly. This is to be controlled by the plant operator.
 - 3) Discharge the mixture continuously and uniformly onto an elevator or conveyor that discharges into a hot mixture storage unit meeting requirements of [Article 2001.22, L.](#)
 - 4) Continue the mixing until the asphalt binder is uniformly distributed and the aggregate particles are uniformly coated.
- b. The plant may be modified with a pugmill coater. The coater shall be inclined and positioned as an integral built-in unit, located between the drum and the hot elevator of the plant setup. Introduce the asphalt binder, and additives when furnished, continuously and uniformly at the lower end of the coater. This shall be controlled by the plant operator. Obtain the Engineer's approval for each plant modified.
- c. When adding RAP, modify drum mixing equipment to process RAP according to [Article 2001.22, A.](#)

L. Hot Mixture Storage.

1. Provide suitable hot mixture storage when the hot mixture is not hauled immediately to the project and placed.
2. Use hot mixture storage bins that are either 1) surge bins to balance production capacity with hauling and placing capacity; or 2) storage bins which are heated and/or insulated and have a controlled atmosphere around the mixture. Use hot mixture storage bins that:
 - a. Are round or octagonal in shape and designed for the intended use.
 - b. Fill using an enclosed system, unless skip conveyors are used.
 - c. Dump material directly into trucks through quick opening and quick closing gates.
 - d. Do not result in significant segregation, damage, or cooling.
3. To each bin, affix an indicating or control device which:
 - Is visible to the loading operator, and
 - Allows control of material remaining in the bin.
4. Limit the holding time to 4 hours in storage bins.
5. Use hot mixture placed in storage bins within 24 hours of production, unless the Engineer approves otherwise.

M. Safety Requirements.

1. Place adequate and safe stairways, platforms, and guarded ladders to plant units at points required for accessibility to sampling locations and other plant operations.
2. Guard and protect all gears, pulleys, chains, sprockets, and other moving parts.

3. Maintain ample and unobstructed passage for personnel at all times in and around the truck loading area. Protect this area from falling material.
4. Ensure bins comply with the requirements of [Article 2001.06](#).

N. Plant Calibrations.

1. Provide personnel, weighing devices, test weights, and equipment for calibration of the plant and verifying accuracy of proportions.
2. Provide sufficient space between aggregate feeds and elevators to permit taking of samples of the discharge for accurate calibration and control of rate of feed.
3. Weigh samples of sufficient size for calibration and checking of proportions.
4. Ensure truck sampling and weighing is acceptable.
5. Allow the Engineer every opportunity to witness calibration of the equipment during the Engineer's normal working hours, or at a mutually agreeable time. This schedule limitation will be modified, if necessary, for work to be done under an accelerated work schedule.
6. Ensure the Engineer's representative indicates witnessing the calibration by signing the calibration documents and charts.