# Recommended
# Quality Control Sampling and Testing Guidelines
# For
# Cold Recycling Using Bituminous Recycling Agents
## CR301

**Revised: 3/27/2023**

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## NOTICE

**It is not intended or recommended that these guidelines be used verbatim within a specification. Owner Agencies should use them to help establish their particular project specification. Owner Agencies should understand that all geographical areas and pavement rehabilitation/preservation projects are unique and the availability of materials and equipment may vary as well. ARRA assumes no liability for utilization of these guidelines by any Individual or Entity. Contact ARRA for answers to questions and for a list of ARRA member Contractors and Suppliers.**

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## 1. General

Quality Control (QC) sampling, testing and inspection shall be conducted by the Contractor to ensure optimum performance of cold recycling (CR). QC shall be conducted in accordance with the procedures outlined in Table 1 and below. Additional sampling and testing shall be conducted if significant changes in Reclaimed Asphalt Pavement (RAP) characteristics are observed, such as a much coarser or finer gradation, a noticeable difference in binder content, or when considerable variability is occurring in field test results.

The Contractor's testing personnel and laboratory shall be certified in the applicable test methods and/or approved by the Owner Agency prior to beginning CR. All testing performed by the Contractor shall be provided to the Owner Agency, when requested, within two business days of obtaining results.

If test results conducted during the placement of the CR do not meet requirements presented in Table 1 the Owner Agency shall be immediately notified. The roadway shall then be inspected and monitored prior to the application of the surface course and any resultant deficiencies shall be rectified as per *ARRA CR101 - Recommended Construction Guidelines For Cold In-place Recycling (CIR) Using Bituminous Recycling Agents* or *ARRA CR102 - Recommended Construction Guidelines For Cold Central Plant Recycling (CCPR) Using Bituminous Recycling Agents*.

**User Note:** These QC guidelines identify suggested material sampling and testing methods that are related to CR process control to maximize final product performance. To adjust for varying field conditions during CR pavement production, changes in rolling patterns, moisture content, recycling agent content and additive content may be necessary to obtain optimum performance. When taking material samples, the time between sampling and testing may affect the results obtained. The Contractor should consult with the Material Supplier to ensure proper timelines are followed so as to ensure accurate test results.

## 2. Mixing Equipment Calibration

Mixing equipment shall be calibrated at the start of every year and monitored throughout the year to ensure accuracy, as outlined in Section 2.0 of Table 1. Mixing equipment shall be calibrated by delivering known quantities of RAP, bituminous recycling agent and water through the recycling equipment to verify that the materials are delivered to the accuracy specified. If during construction the actual delivery rates, determined by volumetric distribution, vary by more than 10% of the desired application rate the equipment shall be recalibrated.

**User Note:** CR equipment should be checked for accuracy during construction. However, due to practical constraints such as varying unit weights of materials, irregular widths during recycling, and non-level surfaces for tank measurements, a 10% tolerance is normally sufficient to verify the equipment remains properly calibrated.

## 3. Bituminous Recycling Agent Compliance

The bituminous recycling agent shall be established by a mix design prior to the start of cold recycling in accordance with guidelines presented in *ARRA CR201 - Recommended Mix Design Guidelines For Cold Recycling Using Emulsified Asphalt Recycling Agents* or *ARRA CR202 - Recommended Mix Design Guidelines For Cold Recycling Using Foamed (Expanded) Asphalt Recycling Agents*. If actual test results conducted during CR do not meet the requirements of Section 3 of Table 1, the Owner Agency shall be immediately notified. The roadway shall then be inspected and monitored prior to the application of any surface course. Resultant deficiencies shall be rectified as per *ARRA CR101* or *ARRA CR102*.

**User Note:** Bituminous recycling agents used for the CR process should be selected to obtain optimum performance and mix workability. They should be established by a mix design prior to the start of the process. The recycling agent selected for a particular project will depend on environmental conditions and material availability, and should follow guidelines presented in *ARRA CR201* or *ARRA CR202*.

### 3.1 Bituminous Recycling Agent Injection Rate

At the start of production the optimum bituminous recycling agent rates established by the mix design shall be followed and, when necessary, modified to within the tolerances established in the mix design to adjust for changing field conditions. Bituminous recycling agents shall be transported to the site in bulk tankers. The application rate of bituminous recycling agent shall be checked by evaluating the mass of recycled material against the volume of recycling agent used for a single tanker, as presented in Section 3.1 of Table 1. If field conditions or performance indicate the need for an adjustment to the application rate, adjustments shall be made in no more than 0.2 percent increments. If the actual applied rate does not fall within the mix design tolerance, the performance of the roadway shall be monitored prior to application of the surface course. Resultant deficiencies shall be rectified as per *ARRA CR101* or *ARRA CR102*.

### 3.2 Foamed Asphalt Compliance

Asphalt binder used for foaming shall be the same Performance Grade (PG), from the same source, as used in the mix design. Polymer modified asphalt binders shall not be used. A certificate of analysis (COA) shall be provided by the Material Supplier with each delivery of asphalt binder or a sample from the delivery tanker may be tested for verification in lieu of the COA. Asphalt shall comply with the QC procedures outlined in Section 3.2.1 of Table 1. Asphalt temperature shall comply with the QC procedures outlined in Section 3.2.2 of Table 1. Before connecting a tanker to the recycling unit or mixer, the temperature of the asphalt shall be checked using a thermometer independent of that fitted to the tanker. A means of subsequent heating shall be available on site in the event that the asphalt is not delivered at the appropriate temperature. Any asphalt that has been heated above the maximum specified temperature of 375 °F (190 °C) shall not be used and shall be removed from the site.

**User Note:** Hand-held digital thermometers have been found to be the most effective way to obtain this temperature measurement.

Foamed asphalt expansion ratio and half-life shall be checked using the test nozzle on the recycling unit or mixer according to Section 3.2.3 of Table 1 for each load of asphalt delivered to the site. If a test nozzle is not present, the asphalt temperature shall be maintained within ± 9 °F (5 °C) of the specified application temperature designated by the mix design. The asphalt temperature shall be recorded and foam testing performed in the laboratory at the recorded temperature to verify foaming characteristics.

### 3.3 Emulsified Asphalt Recycling Agent Compliance

Emulsified asphalt supplied in the field shall meet the penetration, percent residue, and polymer modification (if applicable) properties presented in the mix design and within the tolerances prescribed in Section 3.3.1 of Table 1. A COA shall be provided by the Material Supplier with each delivery of emulsified asphalt or a sample from the delivery tanker may be tested for verification in lieu of the COA. Emulsified asphalt temperature shall comply with the QC procedures outlined in Section 3.3.2 of Table 1.

## 4. Recycling Additive Compliance

Recycling additives shall be cement (dry or slurry), lime slurry, corrective aggregate or a combination thereof. The need for a recycling additive shall be established by a mix design prior to the start of cold recycling in accordance with guidelines presented in *ARRA CR201* or *ARRA CR202*.

**User Note:** Recycling additives are used when the gradation can be improved, as is the case for corrective aggregate, or for faster cure or early strength gain, as is the case for cement or lime. The recycling agent selected for a particular project will depend on environmental conditions and material availability, and should follow the guidelines presented in *ARRA CR201* or *ARRA CR202*. It is important that recycling additives be injected at the rate specified in the mix design to ensure that optimal performance of the CR material is achieved. Improper addition of cement or lime can result in a structurally weak layer, poor durability, excessive cracking or a brittle layer.

**4.1 Cement**

When required by the mix design, cement (portland or blended hydraulic) shall comply with the QC procedures outlined in Section 4.1.1 of Table 1.

When dry cement is spread using a spreader, it shall be applied to the road prior to recycling and the application rate verified according to Section 4.1.2 of Table 1. When the recycling train is fitted with a pugmill, dry cement may be spread in a windrow. However, if the recycling train is not equipped with a pugmill, dry cement shall be spread to the full width of the milling drum to ensure uniform cement distribution throughout the mix. If cement is applied as a windrow in front of the recycling train, a volumetric distribution shall be performed utilizing the weight of cement in the spreader hopper for each load. When spreading cement to the full width of the drum a standard “canvas patch” test, or similar procedure, shall be used to check the application rate. A canvas of known area shall be placed on the existing pavement prior to application of cement. After the cement is spread on the existing pavement, the canvas shall be weighed to verify the application rate.

When cement is applied by means of slurry injection, the consumption of cement (and water) shall be obtained from the computer that controls the slurry mixing unit. A volumetric distribution shall also be performed using the weight of dry cement used in the slurry mixer per load as prescribed in Section 4.1.3 of Table 1.

**4.2 Lime**

When required by the mix design, lime shall comply with the QC procedures outlined in Section 4.2.1 of Table 1. Lime shall be applied by means of slurry injection. The consumption of lime (and water) shall be obtained from the computer that controls the slurry mixing unit. A volumetric distribution shall also be performed using the weight of dry lime used in the slurry mixer per load, as prescribed in Section 4.2.2 of Table 1.

**4.3 Corrective Aggregate Compliance**

When required by the mix design, corrective aggregate shall meet the gradation dictated by the mix design and the physical properties presented in *ARRA CR101* or *ARRA CR102,* and shall comply with the QC procedures outlined in Section 4.3.1 and Section 4.3.2 of Table 1. A COA from an Owner Agency certified Aggregate Supplier may be used in lieu of QC testing.

Corrective aggregate addition rate shall be determined by volumetric distribution utilizing weigh tickets from the haul trucks and the applied area, and shall comply with QC procedures outlined in Section 4.3.3 of Table 1.

**User Note:** Corrective aggregates may be incorporated into the mix to obtain the desired mix characteristics or desired gradation. The gradation of the material will depend on the desired effect but are typically unwashed screenings, chips, continuously graded aggregate or RAP. There should be a

quantifiable improvement in measured mix properties to justify the added expense of corrective aggregates.

## 5. Reclaimed Asphalt Pavement (RAP)

RAP shall consist of asphalt coated material and shall be sampled and tested in accordance with Section 5.1 of Table 1 for maximum particle size, and with Section 5.2 for air dried or wet field gradation. Samples may be obtained prior to or after the addition of recycling agent. If the sample is obtained from the mat, recycled material from the screed shall be placed to replenish the sampled area. Washing of the sample may be necessary. RAP temperature shall be obtained at regular intervals as prescribed in Section 5.3 of Table 1.

**User Note:** Maximum particle size is important to ensure that the texture and consistency in the final CR mat is optimized. A wet sieve analysis in the field provides an indication of the consistency of the RAP and can be used for comparison with the mix design gradation to adjust the bituminous recycling agent rate. RAP temperature is an important parameter to ensure that adequate mixing and bonding of recycling agent to RAP is achieved. RAP temperatures often vary throughout the day; therefore, measurements should be obtained at regular intervals.

## 6. Water

Moisture content shall be controlled to ensure adequate dispersion of the recycling agent and any recycling additives, and to ensure optimum compaction of the cold recycled mixture. Moisture content monitoring shall comply with the QC procedures outlined in Section 6.0 of Table 1. In the event that the rate of emulsified asphalt is modified on site, the rate of water addition shall also be modified to ensure that the total fluids injected remains consistent with the mix design. When foamed asphalt is used, the water injection rate shall not be adjusted unless the modified proctor analysis dictates a change is necessary for adequate compaction of the foamed asphalt mixture.

**User Note:** Cold recycled mixtures with emulsified asphalt and foamed asphalt need to properly cure to reach their full strength. By measuring the moisture content of the CR material, the quality and properties of the CR mixture can be better controlled and adjusted as needed.

When varying emulsified asphalt and water injection rates, experience has shown that a total fluid range between 4.0 - 4.5% must be satisfied. Therefore, minor rate adjustments to either the emulsified asphalt or water may constitute a change to the other liquid.

## 7. Construction

**User Note:** Performance testing (indirect tensile strength, tensile strength ratio, raveling, and Marshall stability) of field produced and either field or laboratory compacted samples as a QC testing requirement for CR materials is not recommended. Variations in environmental conditions (ambient temperatures, curing rates, moisture levels, solar influence, wind, etc.) produce inconsistent test results which make it difficult to establish and control testing results.

Immediate coring of CR materials is not recommended for obtaining performance test samples as a significant amount of time, weeks to months, can be required for the material to fully cure and develop sufficient strength to withstand coring forces.

ARRA is investigating ways to implement performance testing; however, additional research is required to determine reliable field performance testing methods and procedures. At this time, if field testing is

mandated by the Owner Agency, specimens must be compacted within the same timeframe and ambient conditions as field compaction, and should be used for information purposes only. Onsite compacted specimens are the only way to simulate actual construction conditions.

**7.1 Control Strip**

A control strip shall be constructed to determine the optimum (target) density that can be achieved during compaction. The control strip shall be established in accordance with the procedures outlined in *ARRA CR101* or *ARRA CR102* and the QC procedures outlined in Section 7.1 of Table 1.

**7.2 Depth and Cross-Slope**

Depth measurements of milling shall be obtained at available longitudinal joints according to Section 7.2.1 of Table 1.

CR mat cross-slope shall be measured across the mat width before and after compaction to ensure that the desired cross-slope is achieved, according to Section 7.2.2 of Table 1.

**User Note:** Depth and cross-slope requirements for a roadway will vary depending on condition of the existing roadway and operations prescribed in the plans and specifications. For roadways that exhibit a loss of profile outside of a 0.5% tolerance from the desired Cold In-place Recycling (CIR) profile, the plans and specifications should stipulate either a constant milling depth, placement depth, or desired cross-slope i.e. the existing cross-slope is 3.0% and the maximum specified is 2.5%. In this scenario a premilling line item should be included where the profile of the existing roadway prohibits obtaining both a depth and cross-slope. In the event that the existing roadway profile is consistent with the desired CIR profile, both a thickness and cross-slope may be specified.

**7.3 Spreading Depth of Recycled Material**

Probe measurements for spreading depth of placed material shall be made across the width of the mat, along the outside edge, and adjacent to longitudinal joints, according to Section 7.3 of Table 1. When determining the spreading depth, bulking of the CR material needs to be considered. The compacted mat thickness shall be verified for the probe depth being used and adjusted as required to meet the compacted thickness specified.

**User Note:** Typical roll down is approximately 15 to 20% during the compaction process.

**7.4 Mat Width**

Mat width shall comply with the QC procedures outlined in Section 7.4 of Table 1.

**User Note:** Measurement of CR mat width is important where the desired mat width is wider than the existing asphalt pavement.

**7.5 Compaction**

Compacted density shall be determined by evaluating the achieved density in relation to the target density established in the control strip. Testing for compaction shall be in accordance with Section 7.5 of Table 1. If the uniformity of the mixture changes significantly, the target density shall be re-established.

**7.6 Mat Moisture Content after Curing**

Moisture content of the CR pavement shall be measured prior to any secondary compaction and/or placement of the surface course. Mat moisture content shall comply with QC procedures outlined in Section 7.6 of Table 1.

**User Note:** Research and development is currently underway to assess other methods to determine timing of surface course placement that are non-destructive and assess in-place strength of the pavement.

## 8. Surface Tolerance and Smoothness

Surface tolerance shall be measured as a pavement deviation within a 10-foot (3-m) straight edge utilizing a wedge ruler that can slide between the pavement/straight edge interface to accurately measure the gap. Surface tolerance shall comply with QC procedures outlined in Section 8.0 of Table 1. To prevent excessive edge sloughing, the edge of the mat shall be compacted first and compaction progress toward the center or high side.

**User Note:** Surface tolerance is important to ensure that end user comfort is maximized and expected long-term performance of the CR pavement is realized. Use of the International Roughness Index (IRI), Mean Roughness Index (MRI), Profile Index (PI), or Ride Number (RN) for CR pavements has grown as a measurement of smoothness due to acceptance of these methods for both asphalt and concrete pavements. ARRA believes that these techniques can be used successfully for CR pavements; however, substantial evidence does not currently exist to determine specification guidelines for the results obtained. ARRA plans to compile results to establish suggested guidelines in the future.

## Table 1. Quality Control Requirements by Contractor

| Section | Type of Testing | Method | Frequency | Sample Location & Size | Target | Means of Rectification |
|---|---|---|---|---|---|---|
| 2.0 | Mixing Equipment Calibration | Determination of recycling agent and water injection rate as % of weighed RAP | Prior to beginning of work each year and additional, as required[1] | 20 tons (metric tons) of RAP | RAP belt scale: ± 2%<br>Recycling agent meter: ± 2% | Perform maintenance on affected system |
| 3.1 | Bituminous Recycling Agent Injection Rate | Verify amount of recycling agent per mix design and accuracy of meter readings by volumetric distribution | Confirm meter reading every hour and tank distribution once per day | By tank gauging, truck weighing or meter readings and RAP weight by belt scale | Within the tolerances specified in the mix design | Adjust application rate and complete non-conformance report if section outside mix design tolerance |
| 3.2.1 | Asphalt for Foaming | Supplier generated COA[2] or laboratory testing to comply with mix design parameters | Before use of every delivery load | Sample in accordance with AASHTO R 66 or ASTM D140 from delivery truck, 1 gal (4 L) minimum[3] | Meet PG grade requirements | Adjust production settings |
| 3.2.2 | Asphalt Temperature for Foaming | Probe or infrared temperature gun | Before use of every delivery load | Prior to foaming from delivery truck or after inline heating system | Minimum to meet desired expansion ratio and half-life requirements of mix design but not to exceed maximum requirements | Adjust in the field if temperature is too low, return to Supplier if too high |
| 3.2.3 | Foamed Asphalt | Expansion Ratio and Half-life | Before use of every delivery load | Perform with test nozzle into a 5 gal bucket | Maximize both expansion ratio and half-life to meet or exceed the mix design parameters | Adjust temperature and/or water to obtain optimum foaming |
| 3.3.1 | Emulsified Asphalt | Visual sieve test on site[4]<br>Supplier generated COA[2] or laboratory testing to comply with mix design parameters | Before use of every delivery load | Sample in accordance with AASHTO R 66 or ASTM D140 from delivery truck, 1 gal (4 L) minimum[3] | Penetration: ± 25%<br>% Residue: ± 2%<br>Elastic Recovery: 10% at 10 °C, 20 cm, 5 min relax (Elastic Recovery for polymer modification only) | Adjust production settings |
| 3.3.2 | Emulsified Asphalt Temperature | Probe or infrared temperature gun | Before use of every delivery load | From delivery truck | As per the Supplier's recommendations. Not to exceed 160 °F (71 °C) | Adjust production settings |

| Section | Type of Testing | Method | Frequency | Sample Location & Size | Target | Means of Rectification |
|---|---|---|---|---|---|---|
| 4.1.1 | Cement (portland or blended hydraulic) | Supplier generated COA[2] | Before use of every delivery load | N/A | According to *ARRA CR101* or *ARRA CR102* and mix design | Do not use and remove material on site |
| 4.1.2 | Cement Dry Spread Rate | Volumetric distribution | Every half mile (0.8 km) | From windrow or pavement. One canvas patch test | ± 10% of mix design application rate | Adjust application rate and complete non-conformance report if outside tolerance |
| 4.1.3 | Cement Slurry Application Rate | Volumetric distribution<br>% solids by drying or hydrometer | Once for every delivery load | Application rate: one delivery load over area applied<br>% solids from batch tank, 1 qt (1 L) | ± 10% of mix design application rate | Adjust application rate and complete non-conformance report if outside tolerance |
| 4.2.1 | Lime | Supplier generated COA[2] | Before use of every delivery load | N/A | According to *ARRA CR101* or *ARRA CR102* and mix design | Do not use and remove material on site |
| 4.2.2 | Lime Slurry Application Rate | Volumetric distribution<br>% solids by drying or hydrometer | Once for every delivery load | Application rate: one delivery load over area applied<br>% solids from batch tank, 1 qt (1 L) | According to *ARRA CR101* or *ARRA CR102* and mix design | Adjust application rate and complete non-conformance report if outside tolerance |
| 4.3.1 | Corrective Aggregate Gradation | Supplier generated COA[2] or laboratory analysis (AASHTO T 11 and T 27 or ASTM C117 and C136) | Before the start of placement and once every 1,000 tons (metric tons) thereafter | From stockpile, in accordance with AASHTO R 90 or ASTM D75 requirements | According to mix design tolerance in *ARRA CR101* or *ARRA CR102* | Alternate source |
| 4.3.2 | Corrective Aggregate Physical Properties | Supplier generated COA[2] or laboratory analysis (AASHTO T 96, T 176 or ASTM C131, D2419) | Once before placement | From stockpile, in accordance with AASHTO R 90 or ASTM D75 requirements | According to Table 2 of *ARRA CR101* or *ARRA CR102* and mix design | Alternate source |

| Section | Type of Testing | Method | Frequency | Sample Location & Size | Target | Means of Rectification |
|---|---|---|---|---|---|---|
| 4.3.3 | Corrective Aggregate Addition Rate | Volumetric distribution | Every 1/2 mile (0.8 km) | Application rate: one delivery load over area applied | ± 10% of mix design application rate | Adjust aggregate placement |
| 5.1 | RAP Maximum Particle Size | AASHTO T 27<br>ASTM C136<br>Air dried or wet gradation | Start of day and every 1/2 mile (0.8 km) thereafter | Sample in accordance with AASHTO R 97 or ASTM D979 from conveyor belts, windrow, screed, or mat, minimum weight of 5 lbs. (2.5 kg) | 100% passing specified maximum size | Reduce speed of train and/or change screens in crusher |
| 5.2 | RAP Gradation | Air dried or wet gradation measured to No. 30 Sieve | Twice/day for first two days and once/day thereafter or if visual change in gradations occurs | Sample in accordance with AASHTO R 97 or ASTM D979 prior to addition of recycling agent, minimum weight of 22 lbs. (10 kg) | Used to adjust bituminous recycling agent addition rate | N/A |
| 5.3 | RAP Temperature | Probe measurement or infrared temperature gun | At the start of each day and every two hours thereafter | Prior to addition of bituminous recycling agent or via surface temperature of original pavement | > 50 °F (10 °C) to conform with weather limitations presented in *ARRA CR101* or *ARRA CR102* | Suspend recycling until temperature increases |
| 6.0 | Moisture Content of Recycled Mixture | AASHTO T 329<br>AASHTO T 265, ASTM D2216 or ASTM D4643 | Once per every 1/2 mile (0.8 km) minimum | Sample in accordance with AASHTO R 97 or ASTM D979 after all additives have been added to mixture, minimum weight of 20 lbs. (9 kg) | Adjust to achieve desired total fluids content for proper mixing and compaction[5] | Adjust water |
| 7.1 | Control Strip | Nuclear gauge per AASHTO T 355 (ASTM D2950) or Owner Agency equivalent[6] | During the first day and if significant changes in recycled mix properties occur | 1,000 ft. (300 m) | Rolling pattern to establish break over point and maximum target density | N/A |
| 7.2.1 | Depth of Milling[7] | Tape measurement | Every 100 ft. (33 m), recording every tenth measurement | Vertical measurement adjacent to longitudinal joints | Minimum plan or specified depth | Modify as required |

| Section | Type of Testing | Method | Frequency | Sample Location & Size | Target | Means of Rectification |
|---|---|---|---|---|---|---|
| 7.2.2 | Cross-slope[7] | 4 ft. (1 m) Smart level | Every 300 ft. (100 m), recording every fifth measurement | Across mat width after screed and after rolling | ± 0.1% of desired cross fall | Adjust screed cross-slope as necessary |
| 7.3 | Depth of Recycled Material[7] | Depth probe measurement | Ongoing, recording every 1/8 mile (200 m) | Across mat width after screed | Minimum plan and specified depth | Adjust screed height |
| 7.4 | Mat Width | Tape measurement | Ongoing, recording every 1/8 mile (200 m) | Across mat width | ± 2 inches (50 mm) | Adjust paver width |
| 7.5 | Recycled Material Compacted Density[8] | Nuclear gauge AASHTO T 355 (ASTM D2950) or Owner Agency approved method[6] | One per 1/4 lane mile (200 m) | Random sampling as per ASTM D3665 | Individual results within 95-105% of target density | Establish new rolling pattern and target density |
| 7.6 | Mat Moisture Content After Curing | AASHTO T 329 AASHTO T 265, ASTM D2216 or ASTM D4643 | Equivalent to one per day of production | Through full lift depth, minimum weight of 3 lbs. (1.4 kg) | ≤ 3.0% after 3 days or 2 days without rain after 10 days | Wait to dry |
| 8.0 | Surface Tolerance | 10 ft. (3 m) Straight edge | Ongoing, recording every 1/8 mile (200 m) | At joints and ongoing | < 3/8 in. (10 mm) over 10 ft. (3 m) straight edge in any direction | Reworking, rerolling, trimming, milling or abrasive grinding |

**Notes for Table 1**

1. Based on the mixer computer meter readings and other checks, additional calibration may be required. This calibration may require only checking and adjusting the belt scale system using weights. **User Note:** During calibration of the meter, if 3.0% recycling agent is required, based on the allowable tolerance, the meter must deliver the recycling agent between 2.94% to 3.06%. For example, if 8,000 pounds of recycling agent is used, then the tolerance is ± 160 pounds. If the CR is being performed throughout the calendar year, the mixing equipment calibration should be performed annually.

2. A Certificate of Analysis (COA) provided by the Material Supplier that includes test results that verify that the product supplied meets the minimum specified quality standards.

3. Samples shall be stored at non-freezing, non-agitated conditions and they shall be stirred and heated if necessary to achieve homogeneity prior to testing. Emulsified asphalt samples must be tested within 10 days of sampling.

4. Visual sieve test on site according to AASHTO T 59, Section 12, or ASTM D244 using the No.20 sieve modified to only determine if build up exists on the screen.

5. When determining moisture content of the recycled mixture the water component of the emulsified asphalt must also be recognized; however, evaporation of moisture occurs immediately upon injection of emulsified asphalt into the RAP and, therefore, the total amount of water may not be measured during the testing process.

6. It has not been determined at this time if electromagnetic gauges are suitable for use on cold recycled mixtures; therefore, they are not recommended for use.

7. Both the depth and cross-slope requirements for a roadway may not be achievable as described in Section 7.2. CR material will not compact to the milled thicknesses as the RAP will fluff approximately 10-15% after milling and bituminous binder injection, depending on material, methods and environmental factors. Because of this material expansion, the elevation of the final CR pavement may increase compared to the existing pavement. Depending on the road geometry this additional material may be temporarily removed and replaced in areas where minor cross fall corrections are required. Premilling may also be performed if the final CR elevation is to match the existing pavement elevation.

8. Target densities for recycled mix compaction are established using control strips as per *ARRA CR101* or *ARRA CR102*. The compacted density is measured with a nuclear density/moisture gauge in accordance with AASHTO T 355 (ASTM D2950) or local agency approved method, since it is generally not possible to obtain cores during construction. The density obtained will be a “wet density” as conversion to a true “dry density” by the gauge is not possible with CR mixes. A dry density may be obtained by sampling the recycled mix at the nuclear gauge test location, determining the moisture content by drying and correcting the gauge wet density using the sample moisture content.