SAVE MY ROAD

Cold In-Place Recycling (CIR) Using Bituminous Emulsions

Sample Construction Specification Guideline

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.

1. General

Cold In-Place Recycling (CIR) shall consist of milling and pulverizing the top three to four inches of the existing Hot Mix Asphalt (HMA) pavement to the depth, length, and width, as shown on the plans, sizing the Reclaimed Asphalt Pavement (RAP) and blending with a bituminous emulsions, water, and other additives (cement, lime, or corrective RAP or aggregate) as necessary and as required by the mix design to produce a recycled asphalt concrete. This material shall then be placed and compacted in accordance with the plans and specifications, and as directed by the owner agency.

2. Treatment Thickness

The depth of CIR shall be 3 inches (76.2 mm) or as indicated on the plans.

User Note: CIR treatment thicknesses may vary between three and up to five inches (75-125 mm) per lift and should be dependent on structural capacity requirements and project-specific criteria such as original asphalt thickness and expected design life, and the ability of the compactions equipment to achieve density.

3. Preconstruction Personnel Training

Personnel involved with the construction of CIR from both the contractor and owner agency shall have successfully completed Preconstruction Personnel Training (PPT) to ensure that proper quality procedures are followed to construct a high-quality CIR pavement. The PPT shall be conducted at a location convenient for both the contractor and the owner agency. The PPT shall be completed not more than 10 days, not including Saturdays, Sundays, or holidays, prior to the start of CIR operations. The training shall be held during normal working hours. In lieu of this training, proof may be provided showing successful experience has been obtained by the individuals performing the work for the materials and construction techniques to be used in the CIR construction.

The PPT trainer shall be provided by the contractor or owner agency. The PPT trainer shall be experienced in construction methods, materials, and test methods associated with construction of CIR projects. The contractor and the owner agency shall mutually agree to the course instructor, course content, and training site.

User Note: Typically, the PPT is held less than five days before the start of the CIR. It should be close enough to the start of construction so that it is fresh, but also allow some time to address any issues that may be raised during the training.

4. Materials

CIR shall consist of a homogeneous blend of RAP, bituminous emulsions, water, and other additives, if necessary. The actual materials utilized and their respective usage rates are dependent on the mix design and project requirements.

4.1 Reclaimed Asphalt Pavement

RAP shall consist of asphalt cement binder coated material only. The RAP shall be clean, free of contamination of dirt, base, concrete, or other deleterious materials such as silt and clay. The RAP shall be reclaimed from the roadway and sized to meet specific contract requirements. The gradation of the RAP shall be 100% passing the 1.25-inch (31.5-mm) sieve.

RAP from an external location shall be free from dirt, base, concrete, or other deleterious materials such as silt and clay, meet the requirements of Tables 1 and 2, and be included in the mix design.

Table 1 — Additional Crushed RAP

Test	Method	Limit
Deleterious Materials: Clay Lumps and Friable Particles in Aggregate, % max	AASHTO T112	Maximum of 0.2
Deleterious Materials: Clay Lumps and Friable Particles in Aggregate, % max	ASTM C142	Maximum of 0.2
Gradation*	AASHTO T27	100% passing the 1.25-inch (31.5-mm) sieve
Gradation*	ASTM C136	100% passing the 1.25-inch (31.5-mm) sieve

*Gradation only required if the RAP is added after the milling, crushing, and sizing unit.

Rubberized crack filler, pavement markers, loop wires, thermoplastic markers, fabric, and other like materials shall be removed from the roadway during the recycling process as observed. Residual materials that cannot be completely removed from the processed RAP may be incorporated into the recycled mix if the contractor can demonstrate that those added materials will not adversely affect the performance of the recycled asphalt pavement. Any such materials retained in the mix shall be appropriately sized and blended so as not to adversely affect the appearance or strength of the recycled pavement.

In cases where there is an excessive amount of rubberized crack salient, pre-milling the top one inch can be a very effective way of removing problematic materials.

4.1.1 Emulsified Asphalt

Emulsified Asphalt shall be according to the local standards and specifications to achieve appropriate mixing with the RAP. Polymer modification may also be used. The actual emulsion type and applicable usage rate shall be determined by the mix design.

User Note: Typical emulsified asphalts utilized for CIR include CSS-1H Special and/or CIR-EE engineered emulsions.

4.2 Additives (Optional)

Hydrated lime or Portland cement may be utilized as a catalyst at a small dosage rate to increase mix cohesion, to aid in curing, to improve early strength gain, and/or to improve moisture susceptibility (stripping) properties of the CIR material. These additives shall not be utilized with anionic emulsions such as HFE 150. Corrective aggregate may be required to supplement the RAP gradation to meet the performance requirements of the mix design. The usage rate of all additives shall be determined by the mix design.

User Note: If other additives such as fly ash and lime kiln dust are desired, caution should be exercised, as experience with use of these additives is limited.

4.2.1 Portland Cement

Portland cement in either a dry or slurry form may be added to the cold in-place recycled pavement mixture as determined by the mix design. Slurry made from Portland cement shall contain a minimum of 30% dry solids content. Cement shall comply with the latest specifications for Type I or Type II Portland cement (ASTM C150, ASTM C1157, or AASHTO M85). Other types of cements are not allowed. The ratio of residual asphalt in the bituminous recycling agent to dry cement shall be at least 3:1. In addition, the cement shall be limited to 1.0% by dry weight of RAP. At the time of mix design submittal, the contractor shall submit the type of process for incorporating the cement into the recycling process to the owner agency.

4.2.2 Lime Slurry

Lime slurry produced from high-calcium quicklime or hydrated lime may be added to the CIR pavement mixture as determined by the mix design. Lime slurry shall contain a minimum of 30% dry solids content. The dry solids shall be limited to 1.5% by dry weight of RAP. Quicklime or hydrated lime used shall meet requirements of ASTM C977 or AASHTO M216. At the time of the mix design submittal, the contractor shall submit the type of process for incorporating the lime slurry into the recycling process to the owner agency.

4.2.3 Corrective Aggregate

Corrective aggregate may be required to supplement the RAP gradation to meet the performance requirements of the mix. The corrective aggregate gradation will vary according to its size and distribution depending on the effect to the resultant CIR material desired. When required by the mix design, corrective aggregate shall meet the requirements of Table 2.

Table 2 — Corrective Aggregate

Test	Method	Limit
Los Angeles Abrasion Value, % loss	AASHTO T96	40 max
Los Angeles Abrasion Value, % loss	ASTM C131	40 max
Sand Equivalent, %	AASHTO T176	60 minimum
Sand Equivalent, %	ASTM D2419	60 minimum
Washed Gradation	AASHTO T11	As required
Washed Gradation	AASHTO T27	As required
Washed Gradation	ASTM C117	As required
Washed Gradation	ASTM C136	As required
Water Absorption, %	AASHTO T85	3.0 maximum
Water Absorption, %	ASTM C127	3.0 maximum

4.3 Water

Water may be added to the RAP at the milling head and/or in the mixing chamber to achieve uniform mixing and to lubricate the mix to facilitate compaction. Water added to the recycled asphalt concrete shall be clean and free from deleterious concentrations of acids, alkalis, salts, sugar, and other organic, chemical, or deleterious substances. The water shall not cause an adverse effect on either the bituminous emulsion or the recycled pavement mixture. If the water is of questionable quality, it shall be tested in accordance with AASHTO T26 or ASTM C1602, or according to local standards and procedures.

5. Preconstruction Sampling and Mix Design

If not provided by the owner agency, a mix design shall be submitted by the contractor for approval by the owner agency. The mix design shall be performed with representative materials to be encountered during construction of the CIR mix. When the in-place materials change significantly, additional mix designs shall be performed to establish representative mixes for the entire job. Representative samples of the in-place HMA shall be obtained directly from the project site by sampling in accordance with *ARRA CR201 — Preconstruction Sampling and Mix Design Guidelines for Cold Recycling using Bituminous Recycling Agents,* and delivered to an AASHTO or owner-agency-approved laboratory experienced in cold recycled mix designs. At the laboratory, the HMA shall be crushed and mixed with the recycling agent, water, and any additives, if necessary. The mixture shall then be tested in accordance with the mix design guidelines.

Please contact your Sales or Technical Marketing Rep for the most up-to-date mix design guidelines The mix design shall be the baseline measure for the rate of recycling agent application, water, and other additives blended with the RAP to construct the recycled pavement mixture. The mix design shall indicate the allowable tolerance for the Asphalt Emulsion binder, additive, and corrective aggregate so as to not jeopardize the performance of the mix but allow the contractor to adjust the mix so that it may be placed successfully.

6. Equipment

The recycling equipment shall be capable of milling the existing roadway, sizing the resulting RAP, and mixing the RAP with the additives chosen per the mix design. The recycling equipment shall be capable of meeting the specified sizing requirement either with the milling process or with additional sizing equipment. The recycling equipment shall be capable of producing a homogeneous and uniformly coated recycled pavement mixture by mixing the RAP with the emulsion, water, and any other additives either in the milling machine housing or in an additional mixing chamber. The equipment used for placement of the recycled pavement mixture shall be capable of placement to the lines, grades, and guidelines provided herein and shown on the plans. The recycling equipment shall consist of the following major components:

6.1 Pavement Milling Machine

The pavement milling machine shall be self-propelled. The primary milling equipment shall have a minimum 8 feet (2.5 m) cutter capable of removing the existing pavement to the depths shown in the plans. Milling equipment shall be equipped with automatic depth controls capable of maintaining the cutting depth to within 1/4 inch (6 mm) of the desired depth and shall have an effective means for controlling cross slope. The milling operation shall not disturb or damage the underlying material. Use of a heating device to soften the pavement will not be permitted. A smaller milling machine may be used to mill the shoulders and miscellaneous areas.

6.2 Crushing and Sizing Equipment

Crushing or sizing equipment shall be capable of producing RAP to the maximum particle size required prior to mixing the millings with the emulsion. Additional sizing equipment may be necessary in some situations in addition to the milling machine to meet the maximum particle size.

6.3 Mixing and Proportioning Equipment

The properly sized RAP shall be mixed with emulsion, water, and any other additives in the mixing apparatus. The mixing apparatus shall consist of milling machine housing, a separate mixing chamber, or a pugmill. All systems shall be capable of producing a uniformly mixed, homogeneous recycled pavement mixture.

If mixing in the milling machine cutter housing, the additive system shall be computer controlled and automatically adjusted for working speed. The additive shall be introduced at a percentage of weight of RAP calculated volumetrically based on width, depth, and density of RAP.

If utilizing a separate mixing chamber, then the RAP shall be weighed on a conveyor with a calibrated weight bridge immediately before entering the mixing chamber. A computer-controlled additive system shall adjust the binder rate based on the RAP weight automatically.

In both cases, mixing shall continue until a thoroughly and uniformly coated recycled pavement mixture of unchanging appearance is produced at discharge from the mixer.

The emulsion metering device shall be capable of automatically adjusting the flow of emulsion to compensate for any variation in the amount of RAP introduced into the mixing apparatus. The emulsion shall be metered by weight of RAP using a calibrated meter that will accurately measure the amount of emulsion to within a tolerance of +/- 0.5% of the rate required. The mixing apparatus shall have an independent source of water to properly disperse the emulsion. Calibration of the water meter and automatic digital readings shall be displayed for both the RAP flow rate and the emulsion in appropriate units of weight and time.

6.4 Portland Cement or Lime Slurry Storage and Supply Equipment

Portland cement or lime slurry storage and supply equipment shall have agitators or similar equipment to keep the cement or lime slurry in suspension when held in the slurry feed tank. Cement or lime slurry shall be kept in suspension during transport using agitator equipment. The metering system controlling the application of the slurry shall apply the additive within a tolerance of +/- 10% of the desired rate.

6.5 Mixing and Spreading of Dry Cement

Dry cement shall be spread upon the existing asphalt concrete surface ahead of the milling machine using cyclone or screw-type calibrated spreader trucks built to provide a consistent, accurate, and uniform distribution of material. The equipment must apply the additive within a tolerance of +/- 10% of the desired rate.

6.6 Mixing and Spreading of Corrective Aggregate

Corrective aggregate shall be spread in consistent and uniform windrows using belly dump trucks or tailgated with end dumps and spread to a uniform thickness with a motor grader or mechanical spreader in front of the milling machine.

6.7 Paving Equipment

The processed recycled mixture shall be spread uniformly across the recycling width utilizing either a self-propelled paver or a screed integral to the recycling equipment. In either case, the screed shall be controlled by electronic grade and cross slope control. The equipment shall be of sufficient size and power to spread the recycled material in one continuous pass, without segregation, to the lines and grades established by the owner agency and according to the plans. Heating of the screed shall not be permitted. If utilizing a self-propelled paver, material shall either be loaded directly into the paver hopper from the recycling equipment or loaded by a pickup device. If utilizing a pickup device, it shall be capable of removing and transferring the entire windrow of recycled mix in a single pass.

User Note: If a pickup device is utilized, a track paver with a minimum power of 170 hp should be used.

6.8 Water Truck

A water truck for supplying water to the milling equipment during the CIR operation shall be provided. The water truck system shall be able to supply the mixing chamber, if necessary, so as to be capable of providing an independent source of water to properly disperse the emulsion.

6.9 Compaction Equipment

Compacting of the recycled mix shall be completed using self-propelled rollers, complete with properly operating scrapers and water spray systems. The number, weight, and types of rollers shall be as necessary to obtain the required compaction. At a minimum, the following rollers shall be used:

- At least one pneumatic roller with a minimum weight of no less than 24 tons (23 metric tons)
- At least one double-drum vibratory steel-wheeled roller weighing at least 10 tons (9 metric tons)

Rollers shall have a width of no less than 65 inches (1.65 m). Tires on the pneumatic rollers shall be evenly inflated and matched in size and profile so as to maximize compactive effort.

6.10 Fog Sealing and Sand Spreading Equipment

Fog sealing with either a CSS-1H and OR SS-1H 50/50 shall be applied using a distributor truck specifically manufactured for the purpose of sealing/spreading emulsified asphalt at a uniform rate over the full width of a traffic lane in a single application. Sand blotter, if required, shall be spread with a self-propelled screening or salt spreader equipped with a mechanical device that spreads the sand at a uniform rate over the full width of a traffic lane in a single application.

7. Construction

Prior to the start of construction, employees representing both the contractor and owner agency shall submit certification of PPT to ensure the CIR is constructed properly.

Throughout the mixing, placement, and compaction of the recycled mixture, adjustments may be made to the emulsion, water, and any additives so as to provide an optimum product. All adjustments must be recorded and submitted to the owner agency.

7.1 Roadway Preparation

Before any recycling work begins, the contractor shall prepare the existing roadway by:

1) Removing from the roadway dirt, vegetation, standing water, combustible materials, oils, raised roadway markings, and other objectionable materials by sweeping, blading, or another approved method.
2) Adjusting affected utilities down and filling with cold mix asphalt or accommodating for utilities prior to recycling in some other means to the satisfaction of the owner agency.
3) Accurately referencing the profile and cross slope as shown on the plans for the finished surface of the recycled pavement material.
4) Cold mill along gutters and crosswalks (header cut) as appropriate to prepare for any final overlay. The header cut shall be as indicated on the plans.
5) Correct any known areas of soft or yielding subgrade.

7.2 Weather Limitations

CIR operations shall only be performed when the roadway surface temperature is above 50°F (10°C) and rising and forecasted to be to 60°F (16°C) or greater with overnight ambient temperatures above 35°F (2°C with no freezing temperatures forecasted for 24 hours after placement).

7.3 Control Strip

During the first day of production, a control strip shall be constructed to prove to the owner agency that the construction will meet specification requirements. The control strip shall be at least 1,000 feet (300 meters) in length for the contractor to prove that the construction meets the requirements, including:

A. Demonstrating that the equipment, materials, and processes proposed can produce a recycled pavement material layer that conforms to the requirements;
B. Determine the optimal rates for emulsion, water, and any additives recommended for the RAP; and
C. Determine the sequence and manner of rolling necessary to obtain the density requirements.

CIR operations may continue through the first day, unless the contractor's equipment and process fail to meet the requirements for successful completion of CIR operations. Recycling operations shall not continue beyond the first day unless a control strip has been approved by the owner agency. Control strips that do not meet the requirements shall be reworked, recompacted, or removed and replaced at the contractor's expense. Upon acceptance of the control strip by the owner agency, the contractor shall use the same equipment, materials, and construction methods for the remainder of recycling operations, unless adjustments made by the contractor are approved by the owner agency. If adjustments are made, the contractor shall produce a new control strip.

In lieu of a control strip, the owner may allow the contractor to provide proof, based on previous experience with the same equipment, personnel, and materials, that the work will conform to the requirements.

A rolling pattern shall be determined during the control strip to achieve optimum field density. The contractor shall provide a sequence and manner of rolling that will define maximum compaction by establishing a rolling vs. density chart that shows the progress of densification from initial lay down through maximum obtainable density at the "break over point" using a properly calibrated nuclear density gauge per ASTM D2950 or other owner-agency-approved method. The contractor shall determine relative compaction per ASTM D2950 or other owner agency-approved method on the quantity within the control strip. If the relative compaction within the control strip does not meet the density requirements, the contractor shall construct an additional control strip to determine the maximum density obtainable for the recycled material being produced under the same site conditions. The rolling pattern determined shall be strictly followed to ensure compaction is met for the entire CIR surface area. Precautions shall be exercised to ensure that material is not picked up on the drums or tires of the compaction equipment.

User Note: There is not an AASHTO equivalent for ASTM D2950 Density of Bituminous Concrete in Place by Nuclear Methods. Many owner agencies have developed their own test methods for determining density of bituminous mixtures using nuclear methods, and these procedures are acceptable substitutions.

7.4 Mixing and Spreading of Additives

Cement or lime slurry may be added directly to the mixing chamber or sprayed over the cutting teeth of the milling machine. The contractor shall provide the owner agency with slurry batch logs daily.

Cement or lime slurry storage and supply equipment shall have agitators or similar equipment to keep the cement or lime slurry in suspension when held in the slurry feed tank. Cement slurry shall be kept in suspension during transport using agitator equipment.

If dry cement or corrective aggregate is utilized during CIR construction, the desired material shall be spread upon the existing asphalt concrete surface ahead of the milling operation. The distance between the spreader and the milling operation shall be reduced appropriately during windy days. In no case shall cement be allowed to remain exposed at the end of the work day. Dust control measures shall be employed to minimize fugitive dust. No traffic other than construction equipment shall be allowed to pass over the spread cement or corrective aggregate until the recycling operation is complete.

7.5 Processing of Placement of Recycled Mix

The existing HMA shall be milled and pulverized to the length, depth, and width as shown on the plans. The RAP shall be crushed and sized to the maximum particle size specified; blended with the desired rate of emulsion, water, and additives (if required) as dictated by the mix design; or as adjusted within the field to produce a uniform and homogeneous recycled mixture. The recycled pavement mixture shall exit from the mixing chamber in a manner that prevents particle segregation. The recycled mixture shall be spread using a screed to the design elevations. Care shall be exercised while spreading to avoid segregation, tearing, or scarring of the final compacted surface. Handwork of CIR pavement shall be minimized, and care shall be taken to prevent segregation. The wings of the paver shall be operated in an up position or regularly emptied to prevent build-up and minimize segregation. Build-up of material on the edges of the screed shall not be permitted.

The contractor shall ensure that there is no gap of unrecycled pavement material created between successive cuts (along the same longitudinal cut line), nor wedges of unrecycled pavement material created by the entry of the milling drum into the existing material. Longitudinal joints between successive cuts shall overlap a minimum of three inches (75 mm), and transverse joints shall overlap a minimum of two feet (0.6 m).

When a paving fabric is encountered during the cold milling operation, the contractor shall make the necessary changes in equipment or operations so that incorporation of the shredded fabric in the recycled material does not affect the performance parameters of the recycled pavement, or inhibit placing or compaction of the CIR pavement. The contractor shall be required to remove and properly dispose of oversized pieces of paving fabric as directed by the owner agency.

Rubberized crack filler, pavement markers, loop wires, thermoplastic markers, and other similar materials shall be removed as observed from the roadway during the recycling process. Residual materials that cannot be completely removed from the processed RAP may be incorporated into the recycled mix if the contractor can demonstrate that those added materials will not adversely affect the performance of the recycled asphalt pavement. Any such materials retained in the mix shall be appropriately sized and blended so as not to adversely affect the appearance or strength of the recycled pavement.

7.6 Compaction

The contractor shall determine the time from which the treated material is placed until compaction can commence. Rolling patterns shall be established in the field by the contractor and verified by the owner agency to achieve a maximum density determined by nuclear density testing. A rolling pattern for compaction shall be determined such that no increase in density is shown on successive nuclear density tests per ASTM D2950 or owner-agency-approved procedure for any additional passes of the compaction equipment once the maximum density pattern has been identified (“break over point”). Nuclear density testing shall be repeated per ASTM D2950 or owner-approved method throughout the time compaction is being completed to continuously verify the compaction is within +/- 5% of the maximum density established.

The recycled mat shall be continuously observed during compaction efforts. If moisture cracking occurs under the vibratory compaction mode, the vibrators shall be turned off and static rolling only applied. If moisture cracking of the mat continues under static steel rolling, steel drum compaction shall cease, the mat shall be allowed to cure for a time in order for some moisture to escape, and pneumatic rolling commenced, followed by steel rolling to correct irregularities from the rubber-tired roller(s). This procedure shall be followed until there is no longer any displacement of the mat observed by roller action on the recycled surface.

The selected rolling pattern shall be followed unless changes in the recycled mix or placement conditions occur and a new rolling pattern is established at that time. Any type of rolling that causes cracking, major displacement, and/or any other type of pavement distress shall be discontinued until such time as the problem can be resolved. Discontinuation and commencement of rolling operations shall be at the discretion of the owner agency.

Extra care shall be taken to ensure that aggregate from the recycled mixture does not stick to the drums or wheels of the rollers. Water shall be uniformly applied to the wheels and drums, along with mechanical means, if necessary, so as to keep aggregate from sticking. Sufficient water shall be applied to keep rollers and tires clean but not so much that water pools or ponds on the recycled surface.

Rollers shall not be started or stopped on uncompacted recycled material. Rolling patterns shall be established so that starting and stopping shall be on previously compacted material or the adjacent, existing surfacing.

User Note: Again, there is not an AASHTO equivalent for ASTM D2950 Density of Bituminous Concrete in Place by Nuclear Methods. Many owner agencies have developed their own test methods for determining density of bituminous mixtures using nuclear methods, and these procedures are acceptable substitutions. The time to begin compaction operations is dependent on if a lime or cement additive is incorporated as well as climatic conditions.

7.7 Curing

After compaction has been achieved, and prior to opening the cold in-place recycled pavement layer to traffic, a fog seal shall be applied to the recycled pavement surface. The fog seal shall be composed of either CSS-1H or SS-1H emulsified asphalt diluted up to 50% by volume with water or an engineered emulsion diluted up to 60% by volume with water. The fog seal shall be applied at a rate of 0.05 to 0.15 gal/yd^2, (0.2 to 0.7 L/m^2). When a sand blotter is required, it shall be applied to the surface at approximately 1 to 2 lbs/yd^2 (0.5 to 1 kg/m^2). Sand shall be free from clay or organic material. The application rates of the fog seal and sand blotter shall be determined by the contractor and shall be such that a stable and safe roadway surface can be maintained until the surface is overlaid.

Prior to placing the final surfacing or any secondary compaction, if required, the CIR shall meet the following criteria:

1. The completed CIR shall cure for a minimum of five days.
2. The moisture content shall be less than 3.0%. If the moisture content does not fall below the maximum limit of 3.0% after 10 days, and if the roadway has been free of rain for a minimum of two days, the contractor shall be permitted to place the final surfacing or perform the secondary compaction, as required.

User Note: In some areas, secondary compaction is not necessary. It is commonly completed with an emulsified asphalt emulsion but rarely done with foamed asphalt, particularly if cement is added.

7.8 Secondary Compaction

If the emulsion is used, secondary compaction shall be conducted with the pneumatic and steel drum roller after cure and before placing any final surfacing. Secondary compaction shall be completed after the morning sun has risen, when the pavement temperature is at least 80°F (27°C).

A new rolling pattern shall be established to determine the maximum density of secondary compaction. Density of the recycled pavement shall be verified behind the secondary compaction by nuclear density gauge. A rolling pattern for secondary compaction shall be determined such that no increase in density is shown on successive nuclear density tests per ASTM D2950 or owner-agency-approved method for any additional passes of the compaction equipment once the maximum density pattern has been identified. Nuclear density testing shall be repeated throughout the time secondary compaction is being completed to continuously verify that the secondary compaction is within +/- 5% of the maximum density established. Care shall be taken not to over-compact the mat. If cracking results, secondary compaction shall be ceased in that area.

User Note: Consider suspending any secondary compaction if the pavement temperature never reaches 80°F (27°C) prior to scheduled placement of the HMA overlay. In addition, a minimum of four passes should be attempted during the establishment of the rolling pattern for secondary compaction as the density may go down during the initial roller pass. The roller pattern is the number of passes resulting in the peak increase in density. If no increase in density is noted, or if the mat exhibits roller cracking, secondary compaction should be suspended in that area.

7.9 Surface Tolerance

The finished surface and grade of the recycled material shall be checked regularly during placement using a straight edge. The surface tolerance shall not vary more than 3/8 inch (10 mm) from a 10-foot (3.0 m) straight edge placed on the surface in transverse and longitudinal direction. The contractor shall correct humps exceeding this tolerance by reworking, rerolling, trimming, milling, or abrasive grinding. Depressions exceeding this depth shall have a tack coat applied and filled with asphalt concrete (cold mix, recycled mix, warm mix asphalt [WMA], or hot mix asphalt [HMA] just prior to placement of the final surfacing).

7.10 Surfacing

Prior to placing the final surfacing, the recycled pavement should be carefully swept of all loose material to create a dry, clean surface. In the event that an HMA overlay is utilized as the final surfacing, a tack coat of either CSS-1H or SS-1H emulsified asphalt or equivalent at 0.05 gallons per square yard (0.2 L/m^2) minimum shall be applied to all surface areas. A hot asphalt tack coat shall not be used.

7.11 Maintenance

After opening to traffic, the surface of the recycled pavement shall be maintained in a condition suitable for the safe movement of traffic. The contractor shall protect and maintain the recycled surface from nuisance water, other deleterious substances, and/or any other damage. Any damage to the completed recycled material shall be repaired by the contractor prior to the placement of the final surfacing. Areas damaged to the CIR, as outlined in Table 3, shall be repaired in accordance with Table 3. No direct payment will be made for repair, and costs shall be included elsewhere for protection and maintenance of the recycled asphalt concrete pavement. Damage caused by poor subgrade shall be repaired by the contractor as directed by the owner agency. Costs to repair damaged CIR due to the subgrade will be paid by the owner agency.

Table 3 — CIR Damage and Mitigation

Damage	Mitigation
Isolated areas of minor raveling or scuffing.	Sweep and monitor. Determine if re-fog sealing is necessary to protect.
Isolated areas of major raveling, scuffing, or tearing.	Maintain better traffic restrictions in areas that are not cured. Sweep and monitor. Determine if re-fog sealing is necessary to protect. Fill or remove and replace deep damaged areas with asphalt concrete (cold mix, recycled mix, WMA, or HMA) prior to final surfacing.
Large-scale areas of raveling, scuffing, or tearing in straight traffic areas.	Re-recycle or remove and replace to the depth necessary with asphalt concrete (cold mix, recycled mix, WMA, or HMA).
Dimpling due to parked vehicles or equipment.	Fill isolated dimpling with asphalt concrete (cold mix, recycled mix, WMA, or HMA) prior to final surfacing.
Permanent deformation within wheel path areas due to secondary compaction by traffic.	Provide leveling/fill course of asphalt concrete (cold mix, recycled mix, WMA, or HMA) prior to final surfacing or cold mill to remove center hump.
Permanent deformation and shoving due to unstable mix.	Investigate pavement structure in conjunction with mix design lab. Depending on investigation, remove and replace affected areas with asphalt concrete (cold mix, recycled mix, WMA, or HMA) or re-recycle supplementing with uncoated coarse aggregate, additives, and/or emulsion as necessary.

8. Quality Assurance

The contractor shall perform process and quality assurance sampling and testing, and exercise management control to ensure that cold in-place recycling conforms to the project specifications. Sampling and testing shall be performed as outlined in *ARRA CR301 — Recommended Quality Assurance Guidelines for Cold Recycling using a Bituminous Recycling Agent*. The contractor shall provide a qualified technician, testing laboratory, and personnel to perform process and quality assurance sampling and testing during the cold in-place recycling, spreading, compaction, and finishing. The testing laboratory performing the process control and quality assurance testing shall be AASHTO resource accredited. The proficiency of testing laboratories and sampling and testing personnel shall be reviewed and approved by the owner agency prior to providing services to the project. The owner agency shall have unrestricted access to the laboratory, sampling, testing sites, and all information resulting from mix design and quality assurance activities. All quality assurance testing results shall be submitted to the owner agency within 15 business days of construction.

9. Measurement and Payment

Quantities of the produced CIR pavement shall be measured by square yards (square meters) completed and accepted by the owner agency for the depths specified. Emulsion and additive weight shall be based upon certified delivery weigh tickets, less any unused portion. Water used in the CIR operation will not be paid for directly and shall be considered subsidiary to the bid item.

Payment for CIR shall be made at the contract unit price per square yard (square meter). The price shall be full compensation for all labor, materials, tools, equipment, and incidentals; for doing all work involved in cold in-place recycling, complete in-place; for milling, crushing, sizing, mixing, blending, placing, and compacting the recycled pavement mixture; for protection and maintenance of the recycled layer, with the exception of poor sub grade areas; for performing all QA testing including mix design, if required, to be provided by contractor; for PPT training and instructor, if required to be provided by contractor, for fog sealing, sanding, and sweeping if necessary; and for obtaining measurements and recording results of all tests as shown on the plans and as directed by the owner agency.

Bituminous emulsion will be paid for at the contract price per ton (metric ton).

Additives will be paid for by force account if determination is made during the mix design that additives are necessary.

Subgrade repair areas will be paid for by force account.