SECTION 20
TECHNICAL DISCIPLINES

20.1 Overview

The **Asphalt Recycling and Reclaiming Association (ARRA)** is a non-profit international trade association made up of contractors, equipment manufacturers, suppliers, public officials and engineers. Its members are engaged in the recycling and reclaiming of asphalt and are working to build a stronger and safer network of highways, streets and roads across the country and around the world.

ARRA is a forum for the exchange of ideas and solutions to recycling concerns. It will continue to develop new programs, strategies, and funding, not only to improve the technological side of the industry, but to increase the market share for recycled asphalt.

The **Asphalt Recycling and Reclaiming Association (ARRA)** is able to readily respond to the needs of its members and the public for rebuilding a stronger transportation network. A primary purpose of ARRA is to develop and maintain professional guidelines for the recycling industry. This is accomplished through five active technical committees within ARRA. These five technical areas are described in this publication.

20.1.1 Cold In-Place Recycling

The ARRA Cold In-Place Recycling Technical Committee addresses the various methods for recycling of pavements in-place with a cold process. The Committee promotes the process through the distribution of promotional material and technical information.

The Committee has developed a publication, “Guidelines for Cold In-Place Recycling”, which is available from ARRA.

20.1.1.1 Process

Cold in-place recycling is a road construction technique that reuses existing pavement structure. All work takes place on the existing pavement surface and requires no transportation of material. Cold in-place recycling results in a stable road at a total expenditure less than that required by conventional methods.

20.1.1.2 Application

Cold in-place recycling is not a new method of rehabilitating deteriorating roadways. For the last 50 years or more, cold recycling has been practiced by various methods on a wide variety of roadway types. These methods have included the use of rippers, scarifiers, pulvimixers and stabilizers to reclaim existing surface and base materials. Emulsions, cutbacks and other additives have been added and mixed by spraying liq-

uid on a windrow and mixing. Today cold planing machines are being used to pulverize the roadway to the required size while at the same time cutting to a specified depth in preparation for liquid addition. In addition, one of the more recent types of equipment developed for cold in-place recycling is the recycling train. This consists of a cold planer and a screening and crushing unit, which is followed by a mixing and proportioning unit.

20.1.1.3 Advantages

Cold in-place recycling has a number of advantages, including low mobilization costs, reduced haul costs, a very productive process and the use of existing materials in place. In addition, traffic can generally be maintained through the project, the roadway can be open to traffic very quickly, pollution is kept to a minimum, and projects can be completed in a minimal number of working days.

20.1.1.4 Economics

Cost savings have been realized on cold in-place projects in the range of 20 to 40 percent lower than conventional construction techniques. The major areas of savings are utilization of the existing aggregates in the roadway, reduction of haul costs, and the maintenance of the roadway geometry eliminating rework of associated structures.

20.1.2 Full Depth Reclamation

The ARRA Full Depth Reclamation Technical Committee addresses the various methods for reclaiming the materials in a flexible pavement section. The Committee promotes the process through the distribution of promotional material and technical information. The Committee has developed a publication, “Guideline Specifications for Full Depth Reclamation”, which is available from ARRA.

20.1.2.1 Process

Full depth reclamation is a reclamation technique in which the full flexible pavement structure and a predetermined portion of the underlying material are uniformly crushed, pulverized or blended, resulting in a stabilized base course. Further stabilization may be obtained through the use of available additives.

20.1.2.2 Application

Full depth reclamation/stabilization is an increasingly active method of reclaiming flexible pavement sections. Equipment for this process includes rippers, scarifiers, stabilizers, and crushers or pulverizing units. These are used to reclaim the existing asphalt structure and a predetermined depth of the base material. Additives have also been introduced to the processed material for increased stability. Presently, applications include roadways, highways, runways, parking lots, tennis courts and other flexible pavement sections.

20.1.2.3 Advantages

The full depth reclamation/stabilization process addresses the entire pavement section and has proven to conserve natural resources and strengthen base materials

while correcting cross-sections. Additional desired features include faster completion times and public convenience.

20.1.2.4 Economics

Substantial cost savings can be realized with this process through the 100% reuse of existing materials, decreased construction time and reduced handling costs while accomplishing environmental goals.

20.1.3 Hot In-Place Recycling

The ARRA Hot In-Place Recycling Committee addresses the area of in-place recycling utilizing the application of heat and promotes the process through the development of promotional and technical information on the process.

The Committee has developed a publication, “Guideline Specifications for Hot In-Place Recycling”, which is available from ARRA.

20.1.3.1 Process

Hot in-place recycling provides a very low-cost maintenance strategy that enables the public works official to effectively reuse existing materials. This process demonstrates that asphalt is a rather unique construction material in that it can be effectively and economically restored. Rather than bury the deteriorated pavement with inordinate depths of new material conventionally applied, or lose it to the grinder, proponents of hot in-place recycling encourage restoration.

20.1.3.2 Application

Today there are many thousands of miles of asphalt pavements that are excellent candidates for hot in-place recycling. These roadways are structurally adequate and possess a stable base, but exhibit the classic symptoms of pavement distress. Their surfaces are cracked, brittle and irregular, and they are deteriorating at a rapidly accelerating rate.

20.1.3.3 Advantages

Hot in-place recycling effectively addresses the classic symptoms of deteriorated pavement:

- Cracks are interrupted and filled.
- Aggregate stripped of the bitumen is remixed and recoated.
- Ruts and holes are filled, shoves and bumps are leveled, drainage and crowns are re-established.
- Flexibility is restored by chemically rejuvenating the aged and brittle asphalt.
- Aggregate gradation and asphalt content may be modified by some variations of this process.
- Highway safety is enhanced through improved skid resistance.

20.1.3.4 Economics

In a period of rapidly increasing costs and limited funding, hot in-place recycling presents the opportunity to spread available dollars over a much wider area. Roadway deterioration can be suspended, pavements preserved and upgraded, and costly reconstruction avoided.

20.2 Guidelines for Cold in-Place Recycling

20.2.1 Introduction

This nation's transportation system is very important to the survival of our economy. Since World War II, we have built one of the finest surface transportation systems in the world Highways are a very important and integral part of this system. Traffic volume has more than tripled in the last decade, and consequently our existing roads are wearing out faster than they can be rehabilitated or replaced. The costs of new highways are causing the highway industry to look for new approaches to rebuild our existing roads. The highway industry realizes that the best approach to rehabilitation is to reuse as much of the existing roadway material as possible Methods have been developed that are not only cost effective, but also save energy and our depleting natural resources.

Some of the methods in use today are. concrete cracking and seating, concrete recycling, hot asphalt recycling, hot in-place recycling and cold in-place recycling Since over 90% of our hard surfaced roads are asphalt, more emphasis has been placed on methods to recycle existing bituminous surfacing on low volume township and county roads, as well as high volume multi-lane interstate highways and expressways.

Cold recycling has been practiced by various methods and under a variety of names for over half a century. Thanks to cooperation between equipment manufacturers, the petrochemical industry, contractors and contracting agencies, great advances have been made. Today, the process combines sophisticated engineering and testing procedures, microprocessor blending controls, specially formulated additives, and highly productive machinery to achieve both superior quality and economy.

Many contracting agencies that are responsible for maintaining and rebuilding bituminous surfacing are using the cold in-place recycling process. These agencies include. cities, townships, counties, state highways, federal and inter-state highways, and other federal agencies such as the B I.A. and the Army Corps of Engineers.

20.2.2 Cold In-Place Recycling Methods

Cold in-place recycling is a road construction technique that reuses existing pavement structure including, in some cases, the underlying untreated base material. All work takes place on the existing roadway and requires no transportation of material. Cold in-place recycling results in a stable road at a total expenditure of 40 to 50 percent less than that required by conventional construction methods A very important aspect of recycling is the reuse of our depleting natural resources, aggregates and petroleum products.

Cold in-place recycling is not a new method of rehabilitating deteriorating roadways For the last 50 years or more cold recycling, more often called stabilization, has been practiced by various methods. These methods have included rippers, scarifiers, pulvimixers and stabilizers to reclaim the existing surface and base. Emulsions, cutbacks and other additives have been added and mixed by spraying the liquid on a windrow and mixing with a blade, with cross-shaft mixers and various types of traveling plants. In the past, the cold recycled material was laid with a motor grader and compacted with sheepfoot, pneumatic, grid, steel or a combination of rollers.

Today, through the innovations of equipment manufacturers, contracting agencies and contractors, remarkable advancements have been made in the cold in-place recycling process. The most important piece of equipment that has improved the quality and economics of cold recycling is the cold milling machine. Cold milling will pulverize the existing material to near specified size while cutting to a predetermined depth. Cold milling equipment is highly productive, resulting in a cost effective method of rehabilitating a worn-out roadway.

One of the more popular methods developed for cold in-place recycling is the recycling train. This train includes a large cold milling machine pulling a screening and crushing unit followed by a mixing device. The milling machine conveys the pulverized material onto a screen and the oversize pieces are run through a crusher to meet the specified maximum size requirements. The sized material is then conveyed over a weigh belt into the mixing unit. A microprocessor controls the amount of additive to be blended into the material. This unit deposits the processed material in a windrow where it is picked up by a loader attachment on a laydown machine and laid and compacted with conventional hot mix asphalt equipment.

Another aspect of cold recycling that is very important is the liquid additives. Special asphalt derived products such as cationic, anionic and polymer modified emulsions, rejuvenators and recycling agents have been developed especially for the cold in-place recycling process.

Last but not least are the engineering and testing procedures Engineering involves determining the depth and width to be cold recycled, along with the type of additive to be added. Depth is normally determined by the amount of suitable material available. Consideration should be given to the depth of a lift that can be compacted to the specified density. Width of the roadway should be compatible with a standard milling machine mandrel Testing is defined later in this bulletin and is necessary to determine the proper additive and the amount to be added to obtain the maximum density.

20.2.3 Model Specifications for Cold In-Place Recycling

20.2.3.1 Description

This work shall consist of milling the existing bituminous surface to the width and depth shown on the plans, mixing an additive with the pulverized bituminous surface, then spreading and compacting said mixture as shown on the plans and as provided herein.

20.2.3.2 Materials

- The additive shall be the type called for on the plans or in the proposal
- The pulverized bituminous material shall meet the following gradation requirements.

Sieve Size	% Passing
1-1/4”	100
1"	90-100

20.2.3.3 Construction Requirements

- The existing bituminous surfacing shall be cold recycled in a manner that does not disturb the underlying material in the existing roadway. However, in some circumstances a small amount of the base may have to be incorporated in the mix to maintain a constant milling depth.
- Recycling operations shall not be performed when the atmospheric temperature is below 50° Fahrenheit or when the weather is foggy or rainy, or when weather conditions are such that proper mixing, spreading, and compacting of the recycled material cannot be accomplished in the judgment of the project manager.
- When commencing recycling operations, the additive shall be applied to the pulverized bituminous material at the initial design rate determined by the material laboratory The exact application rate of additive will be determined and varied by the project engineer as required by existing pavement conditions. An allowable tolerance of plus or minus 0.2 percent of the initial design rate or project engineer directed rate of application shall be maintained at all times The contractor may add water to the pulverized material to facilitate uniform mixing with the additive. Water may be added prior to or concurrently with the additive and shall not cause any adverse effect on the additive or the recycled material.
- The number, weight and type of rollers shall be sufficient to obtain the required compaction while the mixture is in a workable condition. The project engineer may require a redemonstration of rolling capabilities when a change in the recycled material is observed, whenever a change in the rolling equipment is made or if densities are not being obtained with the rolling pattern being used.

After the recycled material has been spread and compacted, the area may be opened to traffic. Before applying the wearing course, the recycled material shall be allowed to cure such that the free moisture content is reduced to 1 1/2 percent or less.

20.2.3.4 Equipment

- The contractor shall furnish a self-propelled machine capable of pulverizing the existing bituminous materials to the depth shown on the plans in one pass. The machine shall be equipped with standard automatic depth controls and must maintain a constant cutting depth and width. Said machine shall be capable of producing the proper size RAP required or additional screening and crushing will be required

  The equipment shall be capable of mixing the pulverized bituminous material and additive to a homogeneous mixture, and placing the mixture in a windrow or directly into the hopper of a paver The method of depositing the mixed material shall

be such that segregation does not occur.

A positive displacement pump, capable of accurately metering the required quantity of additive, down to a rate of 4 gal/min., into the pulverized bituminous material shall be used Said pump shall be equipped with a positive interlock system which will automatically shut off when the material is not in the mixing chamber

Each mixing machine shall be equipped with a meter capable of registering the rate of flow and total delivery of the additive introduced into the mixture.

- Placing of the recycled bituminous base course shall be accomplished with a self-propelled bituminous paver. The bituminous recycled material shall be spread in one continuous pass, without segregation, to the lines and grades established by the project engineer. When a pick-up machine is used to feed the windrow into the paver hopper, the pick-up machine shall be capable of picking up the entire windrow to the underlying materials.
- The number, weight and type of rollers shall be sufficient to obtain the required compaction while the mixture is in a workable condition. When cold in-place recycling depths of 3" or more, breakdown rolling shall be with a 25 or 30 ton pneumatic roller equipped with a watering device to prevent material from adhering to the tires.

  Rolling shall be performed until no displacement is discerned. Final rolling to eliminate pneumatic tire marks and achieve density shall be done by steel wheel roller(s), either in static or vibratory mode, as required to achieve density.

  Rollers shall not be started or stopped on uncompacted recycled material Rolling shall be established so that starting and stopping will be on previously compacted recycled material or on the existing bituminous roadway, if at all possible.

  Any type of rolling that results in cracking, movement, or other types 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 sole discretion of the project engineer

20.2.3.5 Method Of Measurement

Cold in-place recycling shall be measured by the square yard or by the station The additive of the type shown on the plans will be measured by the ton or gallon.

20.2.4 Advantages of Cold In-Place Recycling

20.2.4.1 Deteriorated Roadways can be Returned to Original Standards:

1. Restores the old pavement to the desired profile, eliminates existing wheel ruts, restores the crown and cross slope, eliminates potholes, irregularities and rough areas.
2. Destroys the existing crack pattern. Alligator cracks as well as transverse and longitudinal cracks are eliminated.
3. Proper testing to determine the additive best suited to the existing material along with the proper proportioning will restore the old pavement to its original properties.

20.2.4.2 Cost Effective:

1. Low mobilization costs.
2. Hauling costs for materials except liquid additives are eliminated.
3. High production. Equipment can cold recycle up to 500 tons per hour.
4. Thin overlay or a chip seal is all that is required for a surface course.
5. All existing materials are reused The only new material required is a small amount of additive.
6. Engineering costs are much lower than for any other type of rehabilitation.

20.2.4.3 Convenience to Traveling Public:

1. One lane traffic can be maintained through project at all times.
2. Full width roadway is open to traffic at night and on weekends.
3. Pollution, including dust, fumes and smoke are at a minimum
4. Projects can be completed in a minimal number of working days.

20.2.4.4 Environmental Advantage

1. Reuses all bituminous material
2. Eliminates hauling and disposal of existing deteriorated surfacing.

20.3 Guideline Specifications for Full Depth Reclamation

20.3.1 Definition

Full depth reclamation is a reclamation technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly crushed, pulverized, or blended, resulting in a stabilized base course; further stabilization may be obtained through the use of available additives.

20.3.2 Introduction

Full depth reclamation is a process that offers economic advantages and design alternatives to pavement restoration.

This process revolves around the ability to pulverize and blend the deteriorated pavement structure to the specified maximum gradation and incorporate that material into the structural design of the restored roadway. Full depth reclamation offers several in-place alternatives to the designer in creating the desired roadway section.

20.3.3 Design

Full depth reclamation does not alter the usual design steps of evaluating existing conditions, determining the cause of pavement failure and deciding the desired project requirements. In many cases, full depth reclamation will prove to be the most economical solution for providing load-carrying capacity. The cost for preparing the existing surface by various methods such as scarifying, preleveling, adding a crushed rock cushion, extra depth pavement overlay or a fabric application will usually be greater than the cost of pulverizing the existing material. By taking advantage of the capability of

introducing liquid additives, additional structural value and cost savings may be realized.

20.3.4 Process

Full depth reclamation consists of three basic steps: pulverizing, introduction of additives and or imported materials; grading and compacting and finally, the application of a wearing surface.

Pulverizing and blending is a mechanical process that physically breaks the pavement material to a usable gradation while incorporating a specified amount of existing base material.

During the mixing phase, materials may be added that will help create the desired base. The percentages of additives are expressed as a percent of the weight of the material being mixed. Most projects will require the addition of water to obtain optimum moisture for proper mixing of material and additives. On some projects the amount of on-site material may not be sufficient to create the desired depth of treated base. In this case imported material to be incorporated into the base can be placed on the existing pavement prior to the mixing pass. After the mixing pass is completed the base material is ready for shaping and compaction. It may be necessary to apply a Fog Seal to the completed base. The Fog Seal will help control raveling and ensure a good bond between the base and the wearing course. In some cases, the Fog Seal may be sanded in order to open the road sooner to traffic.

Full depth reclamation itself can offer many alternatives to the restoration of a particular pavement. All or some combination of the following steps may be found on a full depth reclamation project.

- Cleaning shoulders and ditches
- Pulverizing surface
- Shaping and compacting pulverized material
- Application and mixing of additives such as
  - — imported material
  - — water
  - — asphalt emulsion
  - — cement
  - — lime
  - — calcium chloride
- Shaping and compaction of the treated base material
- Application of a surface course

20.3.5 Sample Specifications for Full Depth Reclamation

20.3.5.1 Description

This work shall consist of the preparation of a stabilized base course composed of a mixture of the existing bituminous concrete pavement and existing base course material. The manufacture of the stabilized base course shall be done by in-place pulveriz-

ing and blending of the existing pavement and base materials, and the introduction of additives if called for in the Special Conditions. The process which results in a stabilized base course, shall be accomplished in accordance with these specifications and conform to the lines and grades shown on the plans or as established by the engineer.

The remaining base material and/or subgrade may be modified to properly accommodate the stabilized base material. Any modification of this nature, if required, such as but not limited to the excavation and replacement of unsuitable materials and shaping and fine grading the subgrade, will be accomplished under separate payment items. Any movement of the stabilized base material for these modifications is also to be accomplished under a separate payment item.

Existing asphalt pavement shall be pulverized by a method that does not damage the material below the plan depth as shown on the appropriate roadway section.

20.3.5.2 Equipment

In general, the contractor has the option to utilize whatever equipment can effectively pulverize and blend the materials. The equipment to be used must also have the capability of introducing liquid additives uniformly and accurately.

20.3.5.3 Application and Mixing of Liquid Additives

Additives shall be uniformly distributed and mixed with the pulverized material and any existing underlying material or imported material as specified. The mixing operation may be accomplished by using either the same machine used for the pulverizing operation or a separate machine designed for in-place continuous mixing approved by the engineer. Regardless of which method is used, a positive displacement variable speed pump and control system capable of metering the additive shall be used.

The mixing machine shall be equipped with a foot per minute instrument that is integral to the variable speed pump controller ensuring that additive can be added only when the machine is moving.

The metering system shall include a totalizer, so the amount of additive used during any given period can be read directly, and a gallons per minute gauge to indicate the instantaneous flow rate during the mixing operation.

The application rate of the additive will be expressed in terms of gallons per square yard. This rate shall be based on the percent by weight of the total mixture as determined by the engineer and shown on the appropriate roadway section. The mixing operation shall be completed in continuous segments. Each segment must be completed and compacted by the end of each day and opened to traffic.

20.3.5.4 Construction Method

The existing pavement and base material shall be pulverized and blended so the entire mass of material shall be uniformly graded and the new additive, if required, shall be uniformly dispersed throughout the processed material.

After the material has been processed, it shall be shaped, graded, and compacted to the lines, grades, and depth as shown on the plans and cross sections. Water may be applied to ensure optimum moisture content at the time of mixing and compaction. The restored cross section shall be thoroughly compacted to not less than ninety-five percent of the maximum dry density or determined by ASTM T99.

The completed stabilized base shall be tested for smoothness and accuracy of grade and if any portions are found to lack the required smoothness or accuracy such portions shall be reshaped and recompacted until the required smoothness and accuracy are obtained. The Special Conditions will indicate the depth of existing base material to be incorporated into the recycling process and also the rate of application of any additives specified.

The pulverized material shall conform to the following gradation:

Sieve Size	**% Passing**
2"	98-100
1-1/2 “	95

Material gradation may vary due to local aggregates and conditions.

20.3.5.5 Payment

Payment will be made under the following:

Item No.	Pay Item	Pay Unit
1	Pulverizing and preparation	Station or square yard
2	Mixing	Station or square yard
3	Additive (if applicable)	
	– Liquid additives	Gallon
	– Mixing water	M-gallons
	– Dry additives	Ton
4	Shaping, compaction and finishing	Station or square yard
5	Imported material	Ton or cubic yard
6	Mobilization	Lump sum
7	Surface treatment	Applicable unit

The price for the items listed above shall be full compensation for all costs incurred for material, labor, tools and equipment for each, complete and in-place

20.3.6 Advantages and Performance of Full Depth Reclamation

- Cost effective method for creating Improved sections and ride quality.
- Eliminates potential reflective cracking of new overlays
- Recycles existing materials saving natural resources and energy.
- Process is accomplished in-place.
- Heating, mixing and hauling costs of conventional maintenance techniques can be eliminated.

- Roadway cross-section can be maintained or adjusted; grade can be lowered in curbed sections to regain curbs or reshaped in poor draining sections to improve drainage.
- Emergency and local traffic can usually continue to use roadway during construction.
- Eliminate material disposal concerns
- Improved resistance to frost penetration of subgrade.
- Savings realized by reducing total pavement thickness

20.4 Guideline Specifications for Hot In-Place Recycling

20.4.1 Introduction

Hot In-Place Recycling is an on-site, in-place method that rehabilitates deteriorated bituminous pavements and thereby minimizes the use of new materials.

This process may be performed as either a single pass (one phase) operation that monolithically recombines the restored pavement with virgin material, or as a two pass procedure, wherein the restored material is recompacted and the application of the new wearing surface then follows a prescribed interim period that separates the process into two distinct phases.

Hot In-Place Recycling provides a very low cost maintenance strategy that enables the public works official to effectively re-use existing materials. This process demonstrates that asphalt is a rather unique construction material in that it can be effectively and economically restored. Rather than bury the deteriorated pavement with inordinate depths of new material conventionally applied, or lose it to the grinder, proponents of Hot In-Place Recycling encourage restoration.

Hot In-Place Recycling effectively addresses the classic symptoms of deteriorated pavement:

- Cracks are interrupted and filled.
- Aggregate stripped of the bitumen is remixed and recoated.
- Ruts and holes are filled, shoves and bumps are leveled, drainage and crowns are re-established.
- Flexibility is restored by chemically rejuvenating the aged and brittle pavement.
- Aggregate gradation and asphalt content may be modified by some variations of this process.
- Enhance highway safety through improved skid resistance.

In a period of rapidly increasing costs and limited funding, hot in-place recycling presents the opportunity to spread available dollars over a much greater area. Roadway deterioration can be suspended, pavements preserved and upgraded, and costly reconstruction avoided.

NOTE

These guideline specifications are meant for the promotion of Hot In-Place Recycling and to provide reasonable assurance to the awarding authority that quality work will be performed by the recycling contractor.

20.4.2 Pre-Bid Considerations

1. Many asphalt pavements are appropriate to Hot In-Place Recycling. Pavement characteristics, relative to depth, mix design, and base stability, should be considered in the selection process.
2. Preliminary evaluation of the deteriorated pavement should be performed in the company of qualified Recycling specialists to verify that the degree of distress is within the capabilities of this process for effective restoration. Localized distortions, failures, or concentration of contaminants may require advance treatment to qualify as a potential candidate.

   A request issued to interested recycling contractors listing basic data, questions, and expectations will be particularly useful, as a means for securing professional input, to agencies unfamiliar with recycling projects.
3. Surface courses containing unusually large aggregate, (i.e., one inch, may not be suitable for Hot In-Place Recycling).
4. Rejuvenation of the aged asphalt is necessary for complete recycling. For bidding purposes, a quantity factor of 10 gallons per square yard inch of undiluted recycling agent should be utilized. However, the awarding authority should have representative cores analyzed to determine.
   a. the penetration or viscosity of the asphalt binder,
   b. the effect on the penetration or viscosity of the asphalt binder by adding varying quantities of recycling agent,
   c. the volume of residual bitumen to reveal the practical limits for additional binding agents.

   The results of these tests should be used to select the type and quantity of asphalt recycling agent or modified new hot mix to be added to the existing material to meet the specific pavement requirements of the owner.
5. Mix design, and depth (volume) of virgin materials to be incorporated in or applied to the restored pavement remain the responsibility of the awarding authority. Specifications for final wearing course mix design can be achieved by using either the “remix” method which provides a thorough recombination of the restored existing mixture with specified virgin materials, or the single pass “repave” method, wherein the virgin materials as specified are placed on top of the restored pavement. Also, the “delay”, method similarly provides for the application of specified virgin materials upon the restored pavement but, after a delay or interim period which separates the recycling and paving phases. Regional climatic conditions, raw material, availability, load bearing consideration, and service requirements shall be, as in conventional resurfacing, the basis for these considerations. Hot In-Place Recycling restores the structural integrity of the recycled pavement to the equivalent of new pavement of similar mix design and its contribution should therefore be considered in the total pavements estimated structural capacity. Depth or volume of virgin materials specified will be affected accordingly.

20.4.3 Guideline Bid Specifications for Hot In-Place Recycling

20.4.3.1 Prequalification Clause

Prospective bidders are hereby informed that prior to construction a complete description of the type of equipment to be used shall be supplied to the engineer. Also, a list of comparable projects performed using this equipment and the techniques specified shall be provided. In lieu of the above, the contractor may qualify his equipment by a demonstration on this or comparable work, at a speed and in a manner the same as he will conduct his operation during actual recycling operations, to the satisfaction of the engineer. The engineer reserves the right to reject equipment he feels is unsuitable. The cost of this demonstration shall be borne by the supplier.

20.4.3.2 Scope

Hot In-Place Recycling consists of furnishing all labor, equipment and materials, and performing all operations with equipment specifically designed to heat and soften the existing asphalt concrete pavement to allow scarifying, or hot rotary mixing, to the depth specified without tensile fracturing the aggregate. The heated scarified material is then thoroughly remixed, redistributed, and leveled either in combination with, or in preparation for rejuvenating agents and virgin materials applied as specified. All work under this item shall be in conformity with typical sections shown on the plans and to the lines and grades established by the engineer.

20.4.3.3 Cleaning and Preparation

Prior to commencing hot in-place recycling operations, the pavement shall be cleaned of all loose material. Power brooms shall be supplemented when necessary by hand brooming and such other tools as required to bring the surface to a clean, suitable condition, free of all deleterious material. Localized patching, remedial conditioning, or structure adjustments should be completed prior to beginning this process.

20.4.3.4 Equipment and Construction Details

1. Single Pass Method
   The equipment for this type shall be self-contained, self-propelled, automated units capable of heating, viscously scarifying and/or hot rotary mixing and redistribution with automatic screed control for longitudinal leveling of either a homogeneous mixture of existing and virgin materials to the specified depth and design (REMIXING), or a similar rehabilitation of the existing asphalt pavement upon which a totally new mix is monolithically applied in accordance with accepted bituminous paving procedures (REPAVING).
   a. Method A: REMIX. The reclaimed material shall be automatically fed into a mixing unit. When required, new hot bituminous pavement material and, when required, a recycling agent or other liquid additive material shall be added to the reclaimed material at the mixer. The type and quantity of the new hot bituminous pavement material and the proportion of new material and reclaimed material shall be specified in the job mix formula. All materials shall then be thoroughly mixed while maintaining the minimum temperature. After mixing, the combined bituminous material shall be

automatically fed into a finishing unit which will spread and level the mixture to the required thickness in conformance with specified cross-section, at a minimum temperature of 240° F.

b. Method B: REPAVE. After the addition of the recycling agent, the reclaimed material shall be gathered by a leveling device equipped with augers for mixing and spread to a uniform depth over the width being processed. After it is placed, and while it still has a residual minimum temperature of 225° F, a layer of new hot bituminous pavement material conforming to the job mix formula shall be placed over it. The application rate of the new material shall be sufficient to provide the required pavement thickness, as shown on the plans.

2. Multiple Pass Method

The equipment for this type shall be a self-contained, self-propelled automated unit capable of heating, viscously scarifying and/or hot rotary mixing, redistributing, and screeding with a controlled leveling at crown and both extremities to insure a cross-section that conforms to the pavement profile specified. Recompaction of the restored material at a minimum temperature of 240° F follows immediately. The application of the final wearing surface follows after a prescribed interval or delay. These materials are applied with conventional equipment in conformance with standard construction techniques.

3. General (Common to all methods)

a. Heating: The equipment used to heat the existing asphalt surface shall fully meet the standards of the state and local Air Pollution Control Authority. The combustion chamber shall be insulated and totally enclosed. Sufficient heat shall be generated to soften the pavement to the depth required to achieve specified performance.

b. Scarifying: The scarifiers or rotary mixers shall be able to both thoroughly remix and recoat aggregate stripped of its bitumen coating and penetrate the pavement surface so as to cut to the specified depth, without tensile fracturing the pavement, to provide a surface conforming to the desired finished profile of the pavement.

c. Recycling Agent Applicator: The liquid spray equipment shall be capable of applying the rejuvenator in a uniform manner across the full width of the processed material and shall incorporate a meter for continuous verification of quantities. The volume applied shall vary in direct proportion to the operating speed of the recycler and shall be synchronized with the volume of material mixed or scarified to maintain a tolerance within 5% of the specified rate.

d. Compaction Equipment: Immediate compaction shall take place with rolling equipment of sufficient type and size to compact either virgin materials or the combined bituminous materials to the required density. State specifications for bituminous concrete surfaces shall apply. Rubber tire compaction equipment is, however, recommended for initial consolidation due to the minimum depth of the recycled or overlay materials.

20.4.3.5 Project Management Details

1. Critical Path
   Sequencing of operations shall be stated by the contractor and approved by the engineer so as to cause a minimum delay in operations and to provide safety for the traveling public.
2. Verification of Depth
   The weight of existing asphalt surface has been estimated to be approximately 144 pounds per cubic foot. On this basis, a minimum of 9 pounds per square foot of existing surface shall be scarified to obtain a depth of between 3/4 and 1 inch. If the tests indicate that the material weighs either less than 137 or more than 151 pounds per cubic foot, the weight per square foot requirement will be adjusted accordingly by the engineer. Additional depths based on similar methods of verification may be specified.
   Scarification will be deemed acceptable when the moving average of three consecutive random weight tests per hour indicates that the required depth has been obtained. The weight of the existing asphalt surface will be determined in accordance with the requirement of AASHTO T-166 from scarified material compacted in accordance with requirements of AASHTO T-245.
   Wherein verification of depth by weight cannot be accomplished, such as projects using the single pass method, effective inspection may require core analysis in combination with an accounting of virgin materials applied to verify depth of restoration.
3. Protection of Existing Improvements
   Since high temperatures are required in a hot in-place recycling operation, the contractor shall exercise care against possible injury or damage to existing improvements. Existing improvements damaged by the contractor shall be repaired or replaced to the satisfaction of the engineer at no cost to the agency.
4. Sampling
   Gradation, bitumen content, density, and smoothness of the bitumen surface course materials will be sampled and tested according to recommended AASHTO guidelines.
5. Measurement and Payment
   Heating, scarifying, leveling and compacting of the pavement shall be paid for at the contract unit price per square yard. Such price shall constitute full compensation for the item as herein described and specified.
   Recycling agent concentrate will be paid for at the contract unit price per gallon by certified weight. The certified weight shall be determined by weighing on sealed scales regularly inspected by the State Bureau of Weights and Measures. The unit price shall include full compensation for furnishing and applying the recycling agent.
   New hot mix asphalt concrete pavement material shall be measured and paid for by the ton.