CHAPTER 9. HOT IN-PLACE RECYCLING (CONSTRUCTION METHODS AND EQUIPMENT)

INTRODUCTION

Hot in-place recycling (HIR) has been described as an on-site, in-place method that rehabilitates deteriorated asphalt pavements and thereby minimizes the use of new materials.[1] Basically, this process consists of four steps: (1) softening of the asphalt pavement surface with heat; (2) scarification and/or mechanical removal of the surface material; (3) mixing of the material with recycling agent, asphalt binder, or new mix; and (4) laydown and paving of the recycled mix on the pavement surface. The primary purpose of hot in-place recycling is to correct surface distresses not caused by structural inadequacy, such as raveling, cracks, ruts and holes, and shoves and bumps. It may be performed as a single-pass operation or a multiple-pass operation. In a single-pass operation the virgin materials are mixed with the restored reclaimed asphalt pavement (RAP) material in a single-pass, whereas in the multi-step process, a new wearing course is added after recompacting the RAP materials. The advantages of hot in-place recycling are that elevations and overhead clearances are preserved, it is comparatively economical, and needs less traffic control than the other rehabilitation techniques. This process can also be used to recoat stripped aggregates, re-establish crown and drainage, modify aggregate gradation and asphalt content, and improve surface frictional resistance. Hot in-place recycling is usually performed to a depth of 20 mm to 50 mm (3/4 to 2 in), with 25 mm (1 in) being a typical depth.

The Asphalt Recycling and Reclamation Association (ARRA) recognizes three basic types of hot in-place recycling processes: (1) surface recycling, (2) repaving, and (3) remixing. Recycling agents for rejuvenating the aged asphalt binder may be added in all the three methods, but virgin aggregate is used only in repaving and remixing operations. The three processes are described below.

Surface Recycling Method and Equipment

The Asphalt Recycling and Reclamation Association (ARRA) defines surface recycling as a rehabilitation process that restores cracked, brittle, and irregular pavement in preparation for a final thin wearing course.[2] Ideal candidates for this process are pavements with stable and adequate base. Although a scarification depth of 50 mm (2 in) can be achieved, depths of 20 mm to 25 mm (3/4 in to 1 in) are common.[3,4] If a hot mix asphalt overlay is placed as a separate operation after surface recycling, the process is referred to as a two-pass method. Otherwise, it is called a single-pass method.

The primary purpose of the surface recycling process is to eliminate surface irregularities and cracks. It is also used to restore the pavement surface to the desirable line, grade, and cross section to ensure proper drainage.[5] Limited and short term surface frictional resistance improvement may also be achieved.[5] Surface recycling has been reported to be successful in removing reflective cracks when used prior to hot mix overlay.[5] This may be more effective if a heater scarifier is used immediately before the overlay to improve the bond between old and new layers.[5]

Figure 9-1[6] shows a schematic of one of the surface recycling process. The equipment consists of a preheating unit, a heating and recycling unit, and a rubber-tired roller. The preheating unit heats up the old HMA pavement surface, the heating and recycling unit applies more heat and scarifies the HMA pavement with a set of non-rotating teeth, and sprays the recycling agent. Then the old pavement and recycling materials are mixed with a standard auger, and leveled off with a screed. A rubber-tired roller is used for compacting the recycled mix. No new aggregate is generally added in the surface recycling process. Figure 9-2 shows a surface recycling process.

Although direct contact with the flame was used initially to heat the HMA pavement surface, at present radiant or infrared heating is used to avoid damage to the asphalt cement binder and prevent undesirable emissions.[7,8,9] Propane is the most commonly used fuel for the indirect heating process.[10] Heating may be carried out with one heating unit with two sets of heaters or two units traveling in tandem, each with a single set of heater. At least two sets of heaters are normally used for heating. The temperature of the HMA pavement is raised to 110°C to 150°C (230°F to 302°F).[11,12] Multiple rows of spring loaded scarifiers are used to scarify the heated pavement. The spring-loaded mounting allows the scarifier to pass over road obstacles such as manhole covers and concrete patches.[10] To eliminate the effect of oxidative hardening due to long term aging, and heating during the recycling process, recycling agents are added to the pavement during the scarifying operation.[5]

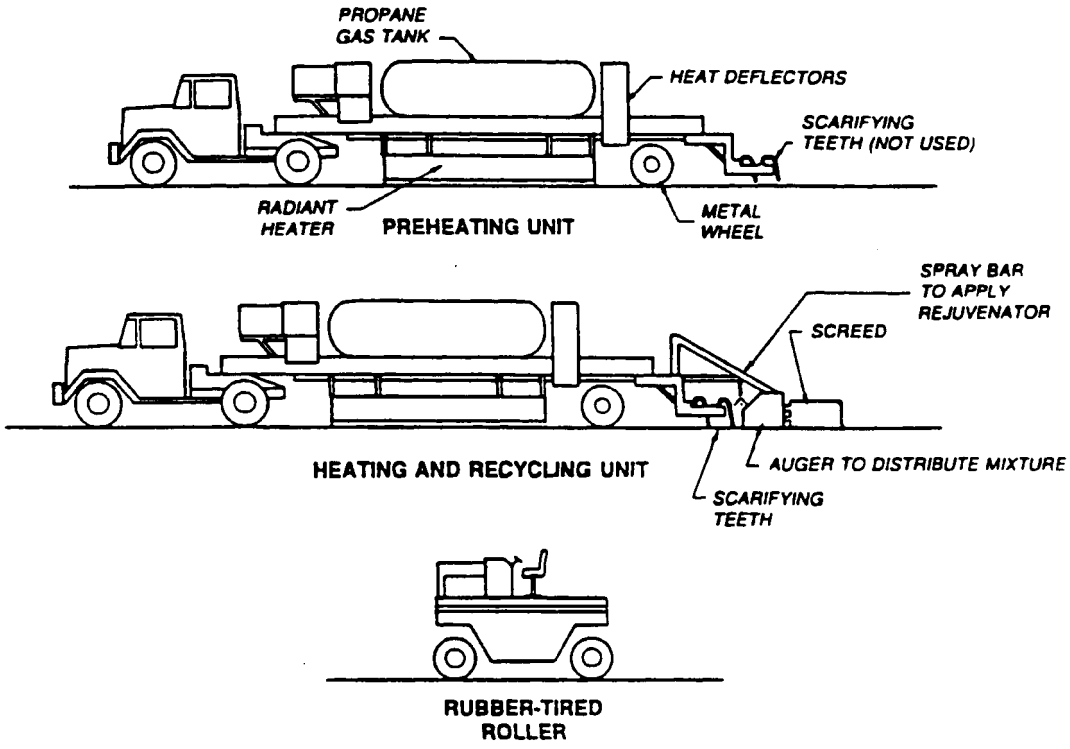

Figure 9-1. A basic surface recycling process.

Figure 9-2. Surface recycling.

Repaving Method and Equipment

Repaving is defined as surface recycling method combined with simultaneous overlay of new hot mix asphalt (HMA) to form a thermal bond between the new and recycled layers.[2] It is basically the surface recycling process followed by an overlay paving process. This process is used to correct the pavement deficiencies in the upper 25 to 50 mm (one or two in) of an existing asphalt pavement.[2] Pavement problems such as minor rutting, shrinkage cracking, and raveling can be eliminated by this method.[2] The repaving process is useful when the surface recycling process is not sufficient to restore the pavement's desirable surface requirements, or when a conventional HMA overlay is impractical or not needed.[5] Very thin overlays (12 mm or 0.5 in) may be used in conjunction with the repaving process to yield good, skid resistant pavements[5] at a much less cost when compared to a conventional HMA overlay process which uses more than 25 mm (1 in) thick overlays.

Figures 9-3 and 9-4[5,6] show schematics of multiple and single-pass repaving process, respectively. The process consist of preheating, heating and scarifying and/or rotary milling, applying and mixing a recycling agent, placing the recycled mix as a leveling course, and finally, placing a new hot mix wearing course.[13] In the single-pass repaving process, two screeds are used—one used to level the scarified HMA mix and the other used to level off the new HMA layer. The steps up to the placement of the recycled mix are similar to those in the surface recycling process. Figure 9-5[6] shows a repaving process. With the first and the second heating units, the pavement is first heated up through forced air or radiant heaters to a temperature of approximately 190°C (374°F) to a depth of 22 mm to 30 mm (0.9 in to 1.2 in).[5] Scarifier teeth

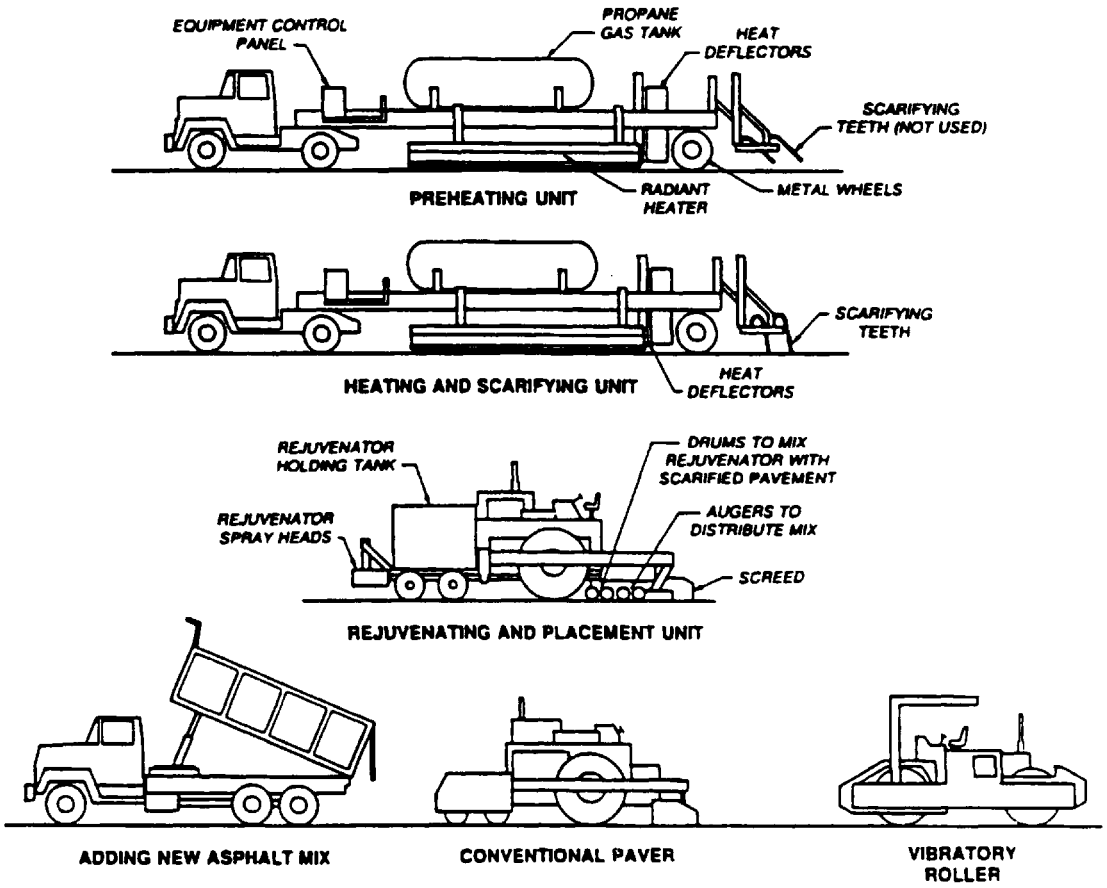

Figure 9-3. Multiple pass repaving process.

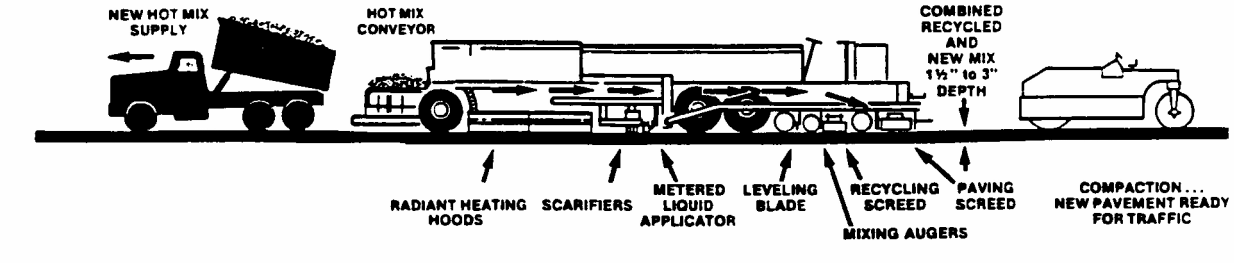

Figure 9-4. Single pass repaving process.

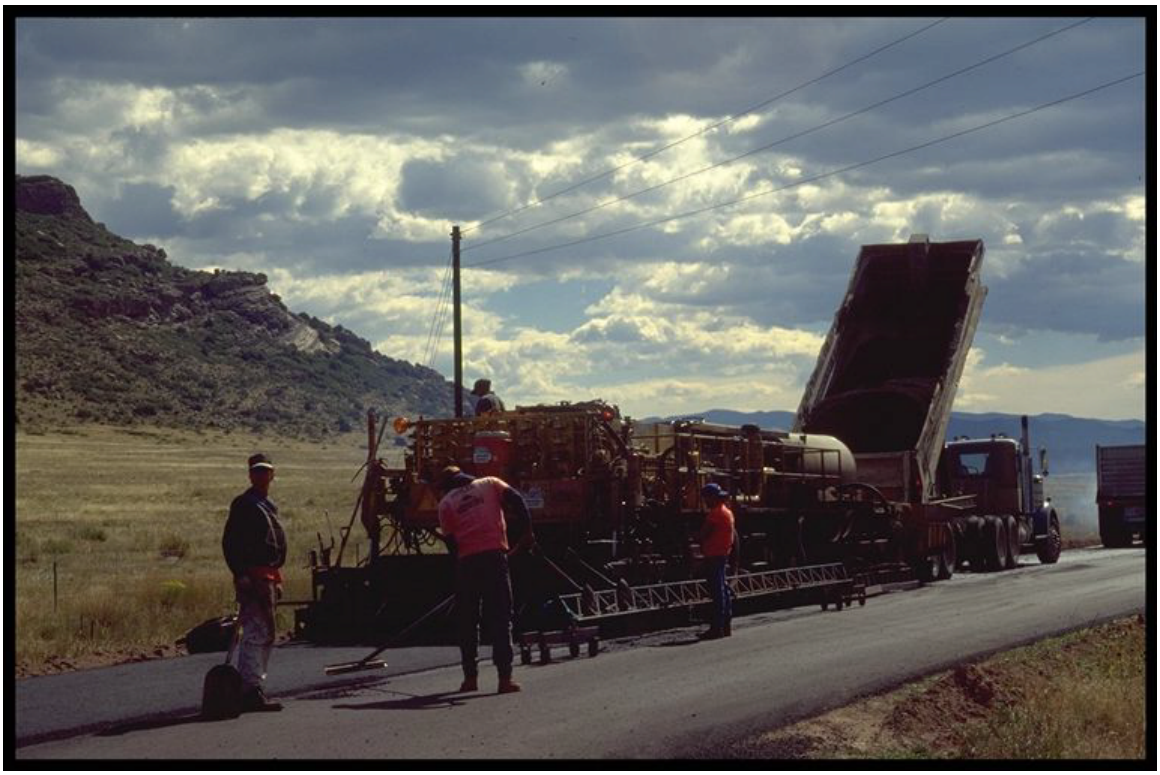

Figure 9-5. Repaving process.

in the second heating unit are then used to scarify the softened HMA pavement to a depth of 20 mm to 25 mm (0.75 in to 1 in).[5] In some systems, individual scarifier tooth or sections of scarifier teeth, mounted in a staggered formation, can be controlled separately to allow scarification to a desired depth and to work around pavement obstacles such as manhole covers.[5] A recycling agent is then added to the scarified material at a predetermined rate. The RAP, along with the applied recycling agent, is then gathered by a blade and then moved transversely into a center windrow with an auger type cross conveyor, which mixes and coats the RAP particles with the recycling agent. Next, the recycled mix is spread in front of the first screed with transverse augers, and partially compacted as a leveling course. Finally, new hot mix asphalt from the hopper is placed on the recycled mix with a second screed. The new mix is placed when the temperature of the recycled mix is approximately 104°C (219°F).[5] Conventional methods immediately after the screed are used to compact the new mix, to ensure monolithic bond between the new and the recycled layer.[14] The screeds used in this method may be with manual or automatic control. In manually controlled screeds, depth measurements are taken with hand and the screeds are adjusted manually, whereas automatic screeds may be completely automated for grade, slope, or depth control. Multiple lifts may be placed in a single-pass machine with two screeds, one trailing the other.[8] Automatic screeds should be equipped with vibrators to achieve some initial compaction.[5]

Remixing Method and Equipment

The Asphalt Recycling and Reclamation Association (ARRA) defines remixing as a process which consists of the following steps: heating of the roadway to a depth of 40 to 50 mm (1½ in to 2 in),

scarification and collection of the softened material into a windrow, mixing of the material with virgin aggregates and recycling agents (and new HMA, if required) in a pugmill, and laying of the recycled mix as a single, homogeneous mix.[2] This procedure is used when repaving method is not sufficient to restore the pavement to its desirable properties and additional aggregates and/or new HMA mix are required to provide strength and stability to the existing pavement.[5] The process can effectively eliminate rutting, cracking, and oxidation (hardening) in the upper 50 mm (2 in) of the pavement surface. Asphalt pavements with one seal coat are remixable, and the seal coat may help in softening the recycled binder. However, pavements with multiple seal coats can create smoke and fire at the surface and act as an insulator against the heating of the underlying pavement.[5]

A schematic concept of the remixing method is shown in figure 9-6.[5] The existing pavement is first heated and softened with a series of infrared heaters in preheating units. The temperature of the asphalt pavement is raised to 85°C to 104°C (185°F to 219°F). The softened material is scarified or milled, and then collected in a windrow. Scarification may be done by stationary tines (or milling heads), and may be followed by an additional set of rotating milling heads. The pavement is generally scarified to a depth of 25 to 40 mm (1 to 1½ in), although more than 50 mm (2 in) can be achieved.[5] A scarification depth of 75 mm (3 in) was achieved in a recycling process in Canada, because of the softer grade of asphalt binder used in the existing pavement.[15] The material from the windrow is carried into a pugmill, where it is combined with a recycling agent and predetermined amount of virgin aggregates or hot mix asphalt, which is dumped from a truck at the front end of the remixing process and stored in a hopper. In some cases the recycling agent is added prior to mixing in the pugmill to allow sufficient time for good dispersion and mixing. The recycled mix is placed in a windrow, from where the material is spread with a set of augers. A vibrating, tamping screed is then used to place and partially compact the material.[5] The exposed surface on which the recycled mix is placed is typically at about 66°C (150°F).[16,17] Finally, the recycled mix is placed with a compacting screed, and

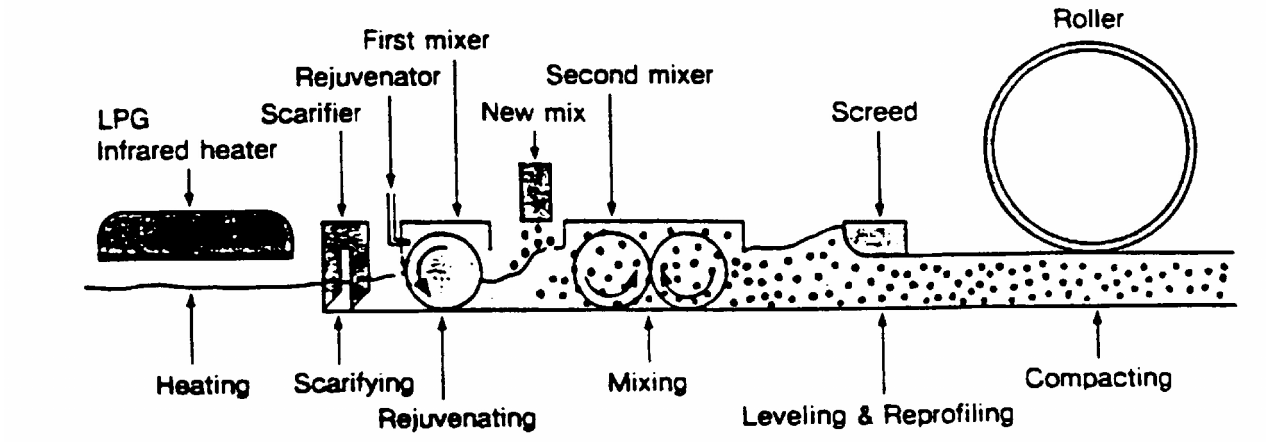

Figure 9-6. Schematic concept of the remixing method.

compacted in the usual method.[15,18,19,20] Figure 9-7 shows a single-pass remixing process. Since remixing uses only 16 to 30 kg/m^2 (42 to 80 lb/yd^2)[5] of new material, fewer haul trucks are required than for conventional HMA overlay operations, and hence results in shorter lane closure time and less disruption to the motoring public.

The use of high intensity infrared heaters tend to overheat and damage the asphalt binder, causing smoke and other undesirable emissions. However, if a less intense heat is applied, aggregate fracturing can occur during milling. To solve this problem, one manufacturer has developed a preheating equipment which uses a combination of hot air and infrared heating system. The application of high velocity hot air in combination with low-level infrared heat is supposed to produce uniform heating of the pavement surface. The recycling train consists of six equipment: two preheaters, one heater miller, one heater miller with paver, rubber tired roller and vibratory roller. A view of the equipment train is shown in figure 9-8.[28]

Emission Control System

A new emission control system has been developed recently, which greatly reduces gaseous hydrocarbon and particulate emissions from the hot in-place recycling equipment.[5] It has been successfully used in the U.S. (Idaho, Montana, and Oregon) and Canada (Alberta, British Columbia, Ontario, and Saskatchewan). The system basically works by collecting the vapor and smoke through a vacuum duct and treating the effluent in an after burner to eliminate undesirable properties.[5] Particulate emissions have generally not been an issue with HIR. However, during HIR operation, joint and crack filling materials can cause flare-ups under preheater. A strip of sand or hydrated lime, 1 mm to 2 mm thick, spread over the filled cracks, has been shown to reduce flare-ups.[21] If there is an excessive amount of crack filling material present on the roadway then the filler may have to be removed prior to recycling.

SUMMARY

Hot in-place recycling has proved to be a very economical pavement rehabilitation strategy which can be used to maintain existing pavements by reusing existing material. However, this process is not suitable for existing asphalt pavements which have too much variation in HMA mix composition within the project limits. The three different types of hot in-place recycling techniques: surface recycling, repaving, and remixing, can be used to achieve different recycling objectives. Surface recycling is used as a process to correct minor surface cracks or irregularities; repaving is used to eliminate rutting, shrinkage cracking, and raveling; and remixing is used to restore the pavement to a greater depth with the addition of virgin aggregate or hot mix asphalt. Whatever the procedure might be, when done in a proper way, hot in-place recycling generally results in savings, and eliminates nonstructural pavement problems with minimum disturbance to traffic, and at the same time maintains the pavement at the existing elevation.

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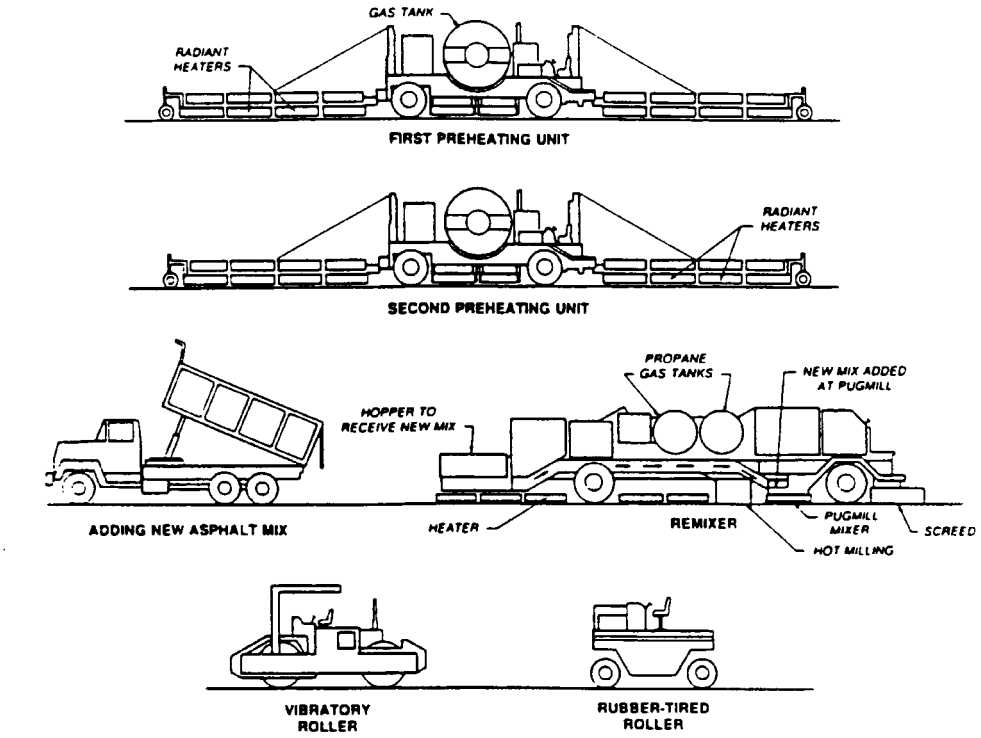

Figure 9-7. Single-pass remixing process showing equipment used.

Figure 9-8. Recycling train with remixer.

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