MDT's Mission is to serve the public by providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality and sensitivity to the environment

CREDITS:

This manual was written and produced by the Maintenance Review Section, Jim Stevenson (Supervisor) and Dan Williams.

The Maintenance Administrator, Chiefs, and Superintendents across the state of Montana have been very helpful in the development and fine-tuning of this manual.

Mike Bousliman, Marty Beatty, Ben Juvan, Dick Wiley, and Jim Hyatt provided additional assistance.

REFERENCES:

The Asphalt Institute's Manual Series No. 19 (MS-19) March 1979 A Basic Asphalt Emulsion Manual and Manual Series No. 4 (MS-4) 1989 The Asphalt Handbook.

Texas State Department of Highways and Public Transportation 1984 Inspector's Training Manual, Seal Coat and Surface Treatments.

Washington State Department of Transportation (Planning, Research, and Public Transportation Divisions) in cooperation with FHWA, WA-RD 136.1 November 1987 Asphalt Seal Coats

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INTRODUCTION

Pavement preventive maintenance is a tool that has the potential to both improve quality and reduce expenditures for our pavement system. Preventive maintenance is based on the concept that periodic inexpensive treatments are more economical than infrequent high cost treatments.

Several types of treatments can be used for preventive maintenance. However, regardless of the type of treatment, proper treatment, timing, materials, construction procedures and quality control will determine if the treatment is successful.

The objective of this manual is to provide MDT Maintenance personnel with:

- Flow of activities from early planning through completion of the project.
- Present materials, equipment, operation and traffic control consideration needed for a successful chip seal.
- Provide a glossary of terms, charts and forms used on a chip seal project.
- Provide some standardization of materials, equipment, techniques and traffic control for a chip seal project.

If a chip seal is not properly designed and constructed, several potential problems can occur. Windshield damage is a common problem that occurs when the chips are not adequately embedded in the asphalt and/or excess chips are used. Another common problem is bleeding or flushing of the asphalt. A high asphalt application rate, inadequate chip coverage, poor traffic techniques, or several other factors can create this. The end result is the loss of skid resistance.

Chip seals, if properly designed and constructed, will provide several benefits to the roadway surface: waterproof the surface, seal small cracks, improve skid resistance, and increased pavement life. However, chip seals will not provide structural capacity to pavement. The existing pavement must be structurally sound to obtain a long performance life.

ACTIVITY NUMBER DESCRIPTION

Activity Number	General Description
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Activity Number	General Description
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600	Start shooting asphalt
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710	Remove traffic control signs
720	Fill out project completion paperwork

CHAPTER 1

CHIP SEAL ACTIVITIES

CHAPTER 1 – CHIP SEAL ACTIVITIES

PAVEMENT PREVENTIVE MAINTENANCE DEFINITION

A program strategy to:

- ***Arrest Light Deterioration***
- ***Retard Progressive Failures***
- ***Reduce The Need For Corrective Maintenance***

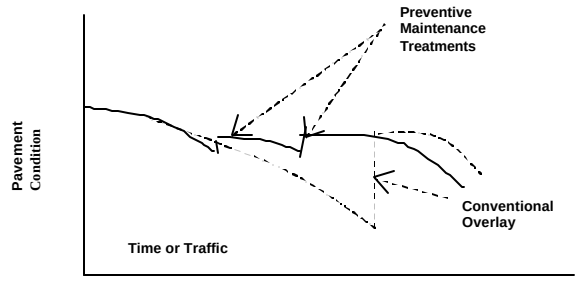
Several different definitions of pavement preventive maintenance exist. However, this definition recognizes preventive maintenance as a program strategy that can arrest light pavement deterioration, retard progressive failures, and/or reduce the need for corrective maintenance.

OBJECTIVE

Keep the pavement condition above a level that would require corrective or routine maintenance strategies.

The objective of a preventive maintenance program is to extend the functional life of the pavement by applying treatments before the pavement deteriorates to a condition that requires corrective treatment such as structural overlays. Relatively inexpensive treatments are used to increase the life of the pavement.

PROGRAM STRATEGY



A pavement preventive maintenance program consists of a series of treatments applied to the pavement over time. These can be a combination of different treatments, such as periodic crack seal treatment followed by a chip seal. The objective of this program is to provide better quality service to the highway user, in terms of both the pavement quality and cost effectiveness.

WHEN SHOULD A PAVEMENT PREVENTIVE MAINTENANCE TREATMENT BE APPLIED?

One of the most important questions is, when should we apply a preventive maintenance treatment?

The need for preventive maintenance of a vehicle is well understood. Equipment preventive maintenance schedules are based on usage, and not the condition of the equipment. THE PAY NOW OR PAY ME LATER CONCEPT. The same concept applies to pavement systems.

TYPICAL PREVENTIVE MAINTENANCE TREATMENTS

- ***Thin Overlay***
- ***Chip Seal***
- ***Crack Seal***

Thin overlays, chip seals and/or crack sealing can be preventive maintenance treatments. However, **PROPER TIMING** of the application is the key to whether the treatment is preventive or not.

OBJECTIVES OF A CHIP SEAL

- ***Provides a Wearing Course***
- ***Waterproofs Surface***
- ***Seals Small Surface Cracks***
- ***Improves Skid Resistance***

A chip seal is a pavement-wearing course. It can also be used to waterproof the surface, seal small surface cracks, and improve surface friction.

A chip seal can extend the life of blade patches by waterproofing and preventing raveling of the blade patches. **Chip seals should be placed on all thin overlays and blade patches.**

Activity 100

REVIEW PAVEMENT DISTRESS DATA

- ***Surface Distress***
- ***Roughness***
- ***Skid Resistance***
- ***Non-Destructive Testing***

Selection of a chip seal depends on the condition of the pavement and the objective of the chip seal. The following information should be considered when evaluating the condition of the pavement: 1) surface distress (i.e., alligator cracking, rutting, etc.), 2) roughness (IRI), 3) skid resistance, and 4) non-destructive testing (Road Rater). All of the distress information is available from the Pavement Management System.

Regardless of the chip seal's objective, a review of the pavement distress data is essential. This data will help you determine life expectancy of the chip seal, whether your objective is preventive or just holding it together.

WHEN TO USE A CHIP SEAL

Distress:

- ***Minor Alligator Cracking***
- ***Severe Alligator Cracking (Temporary)***
- ***Transverse Cracking (Crack Seal First)***
- ***Longitudinal Cracking (Crack Seal First)***
- ***Raveling***
- ***Patches (Will Reduce Raveling)***
- ***Improve Ride***
- ***Improve Skid Resistance***

Placed on all New Overlays

In general, structural distress (alligator cracking) cannot be corrected with a chip seal, which is not to say that a chip seal will not extend the life of a pavement with structural distress. The life of a chip seal placed on an alligator cracked roadway will depend on the severity of the alligator cracking. Some types of distress, crack sealing, will prolong the effectiveness of the chip seal. The crack sealant should be allowed to cure completely prior to placing the chip seal. Raveled pavements and patches are good candidates for chip seals. Chip seals can also improve skid resistance problems.

Chip seals should not be used as a lone strategy to correct rutted or shoving pavements. We do not recommend chip seals on bleeding pavements since the excess asphalt on the pavement surface will bleed though the chip seal.

All new overlays and blade patches should have a chip seal placed on them.

Activity 110

REVIEW PMS OPTIMIZATION PLAN

- ***Review Potential Project List***
- ***Prioritize Projects***
- ***Review Pavement Preservation Budget***
- ***Optimize Project List***

The Pavement Management System's distress information and optimization routine will provide a list of potential projects. Based on the projected pavement preservation budget, project priorities can be established based on their benefit to the entire system.

Activity 120

DEVELOP THREE-YEAR WORK PLAN

- ***Establish Project List***
- ***Establish Project Priorities***
- ***Establish Maintenance Treatments***

A one-, two- and three-year tentative work plan should be established based on the Pavement Management System's distress data. Once the projects are established, the type of maintenance treatment and its objective can be assigned. This process will help you to identify your long-term commitment to preventive and reactive maintenance strategies.

Activity 130

REVIEW PROJECTED BUDGET

- ***Compare Projected Budget to Work Plan***
- ***Revise Project Priorities as Necessary***

After establishing the tentative one- to three-year work plans, compare the project priorities and maintenance treatment to the project budget. Due to budget limitations or spring breakup, project priorities may have to be changed.

Activity 140

MEET WITH DISTRICT AND DIVISION DECISION-MAKERS

- ***Review Proposed Construction Projects for Next Three Years***
- ***Review Proposed Maintenance Projects***
- ***Review Potential Maintenance Crushing Contract***
- ***Come to Consensus on One- to Three-Year Maintenance Plan***

A variety of topics can be handled at this meeting. The Construction Engineer can lay out the proposed construction program that could possibly eliminate a maintenance project, or vice versa. Maintenance could also look at doing a 'preventive' maintenance project on a recently completed construction project, such as crack sealing. If a maintenance project is close to a construction job, consider saving the mobilization costs by attaching maintenance crushing. Are there any poor roads not in the construction program that need thin lift overlays or 'reactive' maintenance? Come to a consensus on a tentative one- to three-year work plan with the District Administrator and other decision-makers.

Activity 150

SELECT TENTATIVE PROJECTS BASED ON ACTIVITY - 140

Select tentative projects and type of treatments based on best available data, observations and meetings. There is a good chance project priorities may change. Consequently, you should develop costs and plans for alternative projects. Remember to plan a chip seal for your thin lift overlays and large blade patching projects.

Activity 160

ESTIMATE QUANTITY OF CHIPS TO BE PURCHASED

- ***Determine Materials on Hand***
- ***Determine Materials to be Purchased***
- ***Can You Afford It?***

You may have a small quantity of chips on hand, but not enough for your projects. You will need to compute the additional tons of chips needed. For estimating purposes, use 25 lbs. per square yard and add 10 percent for chip loss in moving, storing and loading. NOTE: You will need to submit samples of each different source and type of cover material for a chip design.

Do these quantities and costs fit into your projected budget?

Activity 170

ESTIMATE PROJECTED COST FOR EACH PROJECT, TOTAL AND COMPARE TO PROJECTED BUDGET

- ***Aggregate***
- ***Asphalt***
- ***Contracted Services?***
- ***Hauling Costs?***
- ***Leased Site or Equipment?***

You will need to compute all costs for the projects. Total your projects and compare to your projected budget. Be sure to include all expenses for aggregate, asphalt, and any contracted services or equipment rental you may incur. **Be sure mobilization costs are included in your aggregate costs**. Consider 'piggybacking' your crushing onto construction projects and hauling to your project site to reduce costs.

Activity 180

ESTABLISH PROJECT PRIORITY LIST AND TIME FRAMES

- ***Project Priority***
- ***Project Length***
- ***One Year From Start of Project***

After you have assigned costs to projects, your priorities and project lengths may have changed. You should re-address your priorities and make adjustments with the same suggestions in Activity 150.

Activity 190 (Allow 1 yr. to start of project.)

FIELD SUBMITS SMP WORKSHEETS FOR ANNUAL SMP REQUEST

- ***Projected Costs***
- ***Quantities***
- ***Locations***
- ***Construction***
- ***Hauling***
- ***Material Type***
- ***Completion Dates***
- ***Is This on a Reservation?***

Mobilization for crushing is a considerable cost. Mobilization can be reduced by:

1. Addressing all crushing needs at one time. This includes: chips, sand, and aggregate required to produce mix for overlays.
2. 'Piggyback' onto a construction project.
3. Consider hauling materials by comparing haul costs to mobilization cost.

Specify 4A or 5A cover material based on costs, availability, asphalt compatibility and ADT for the project planned. Make sure the completion date of the contract falls in the window of opportunity for chip seal season.

Activity 200 **(Allow 9 mo. to start of project.)**

MAINTENANCE ADMINISTRATOR APPROVES SMP REQUESTS

- ***Quantities***
- ***Locations***
- ***Material Type***
- ***Contract Size***
- ***Existing Stockpiles***
- ***Costs***

Headquarters staff and the Maintenance Administrator will review the SMP requests from a statewide perspective as well as a Division perspective. SMPs are grouped into contracts of varying dollar sizes and location to attract a variety of contractors for bidding. Locations, material types, and quantities are compared to the MMS printout of existing stockpiles and material usage. Divisions are then notified of SMP locations, specifications, and special provisions. Approved SMPs are sent to Contract Plans for bid preparations.

COVER MATERIAL

- ***4A***
- ***5A***
- ***See Chapter 2 on Aggregate Considerations***

4A cover material is a 'cleaner chip,' meaning there are less fines and an emulsion with less water can be used. Typically, a Cationic Rapid Set (CRS-2P or CRS-2LM) is used with 4A material. This combination should be considered with higher ADT roadways.

5A cover material has more fines and an emulsion with more water such as High Floats (HF 100P) is used. This combination stays 'tender' longer and should be considered on lower ADT roadways.

Polymer or latex modifiers should be used since they improve the performance of the asphalt.

Activity 210 **(Allow 8 mo. to start of project.)**

DIVISION MAINTENANCE CHIEF REVIEWS CONTRACT PLANS' SMP SPECIAL PROVISIONS

- ***Wording***
- ***Quantities***
- ***Locations***
- ***Dates***
- ***Details***

The Maintenance Chief should go over the bid from Contract Plans. Make sure the contract states what you want. Look at the material specifications, terminology, dates, quantities, site locations, and all details that will make a good workable contract for you.

Activity 220 **(Allow 6 mo. to start of project.)**

SMP IS BID AND AWARDED

Early planning and attention to detail will ensure your SMP request goes to bid letting on time to meet your needs.

Note: Site preparation is very important for your stockpiles. Make sure you have good drainage and the site is free from contaminants (weeds, rocks, etc.).

See Chapter 2 on Aggregate Considerations.

Activity 230 **(Allow 2-6 mo. to start of project.)**

CONSTRUCTION DIVISION ADMINISTERS SMP CONTRACT

- ***Quality Control***
- ***Quantity***

Personnel from the Construction Division oversees the crushing of the aggregate. They ensure the specified gradations are met, proper quantities are produced, and contractor payments are made.

Activity 240 **(Allow 2 mo. to start of project.)**

SMP COMPLETED

The stockpile is now available for use.

Activity 250 **(Allow 2 mo. to start of project.)**

SUBMITS SAMPLE FOR MIX DESIGN

- ***Quantity***
- ***Quality***
- ***Results***
- ***Re-Testing***

Samples will need to be submitted to the materials lab for a chip seal design. Be sure to submit enough material and use proper sampling techniques when taking samples. Consult your lab. When submitting samples for a design, specify several asphalts for testing. Look at the 'adhesion' results from the stripping test. If you don't have good adhesion, your chips won't stay on the road. Consider using modifiers in your asphalt for extended life of the project. If the chip design indicates an asphalt application rate of less than .30 gal/per/sq.yd., you should resubmit for another design. It's difficult to get adequate imbedment of 3/8" aggregate with less than .30 application rate.

Activity 260 **(Allow 2 mo. to start of project.)**

OBTAIN APPROPRIATE PERMITS

- ***Water***
- ***Material Storage***

Times are changing! If you plan to fill your water truck from an irrigation ditch or stream, you will need to have appropriate permits. You may need to make arrangements or obtain permits to stockpile chips or construct approaches to access temporary chip piles. Environmental considerations are changing rapidly. **Ask if you're not sure.**

Activity 270 **(Allow 6-8 wks. to start of project.)**

SURFACE PREPARATION

- ***Patching***
- ***Crack Sealing/Filling***

Your seal and cover treatment is the 'beauty cream' to water proof, provide a friction surface and moderate irregularities. You will need to make repairs to the roadway prior to the chip seal. Extensive blade patches made with an MC (medium cure) asphalt need about two weeks to cure before you seal them. Less time is required for repairs using emulsified asphalt. Similar curing considerations should be given to crack sealing. Choice of crack seal material will depend on width, frequency, type of cracks and expected life of the repair. Mowing the right-of-way and brooming the surface will help ensure a good job.

Activity 280 **(Allow 6-8 wks. to start of project.)**

ESTABLISH TENTATIVE DATES FOR THE PROJECT AND NOTIFY PERSONNEL

- ***Dates From Start to End of Project***
- ***Location Milepost to Milepost***
- ***Notify Affected Personnel***

Now is the time to set a tentative start date for the project. Communication is important to all participants for their planning. Summer vacations and chip jobs come at the same time of year. Let your employees know when the job is scheduled, where it's going to be, who will likely be needed and perhaps why you've chosen this work and location. This is a good time to talk to the refinery providing the asphalt for your project. Provide them with a schedule of your upcoming projects so they can make arrangements for distributors and shipping.

Activity 290 (Allow 4 wks. to start of project.)

STAGE MATERIALS ON THE PROJECT

- ***Site Preparation***
- ***Multiple Sites***
- ***Quantities***
- ***Access and Safety***

If the chips aren't already on the job, now is the time to get them there. Site preparation is important. Clear and clean the site of anything you don't want going through the chip spreader. Depending on the length of the project, you may want to 'stage' stockpiles along the job to shorten haul distances. Staging stockpiles requires some calculations for quantities. Remember to add 10 percent above your chip design for material loss. Hauling chips can be accomplished anytime the materials are available and any required permits are obtained. When considering your stockpile sites look at sight distance for the traveling public and install 'Trucks Entering' signs where appropriate. There will be water used at these sites, so drainage should be considered. Gumbo would be a problem! Remember, you may have to reclaim your staging areas.

Activity 300 (Allow 4 wks. to start of project.)

SCHEDULE EQUIPMENT NEEDS WITH THE SHOP

- ***List Modifications***
- ***PM 1 or 2***
- ***Mechanic for the Project***
- ***Talk With Shop Foreman About How Much Lead Time Is Needed***

Equipment shops need as much time as possible to prepare equipment for a project, especially when PM 2's come due. A good idea is to have any repairs done, or scheduled to be done at the end of the season. For instance, if at the end of the season you know you would like work done to the chip spreader, schedule to have it done when you have finished with it. That also allows the shop flexibility in scheduling work. Is there any new equipment that may require training or manuals? It is recommended to have a mechanic on the job right from the start of the project. Lots of minor unforeseen problems arise that can be repaired on the spot without holding up the project. One spare tire for each type of vehicle should be on the job as well. Know where to find a backup chip spreader or replacement parts.

Activity 310 (Allow 4 wks. to start of project.)

OBTAIN STRIPING TABS

- ? ***Set Tab Spacing***
- ? ***Determine Quantity***
- ? ***Order Tabs***

You will need to make sure that you have an adequate number of striping tabs. Allow yourself plenty of time if you have to order any. Tabs are available through your store system.

Activity 320 (Allow 2-4 wks. to start of project.)

MEETING WITH ALL SUPERVISORS INVOLVED IN THE PROJECT

- ? ***Equipment Needed***
- ? ***Personnel Needed***
- ? ***Assigned and Delegated Tasks***

The Maintenance Chief, Superintendent and Field Supervisors need to meet and determine what and who is needed for the project. There are many considerations when making assignments, such as what equipment is needed, what is available and what is it's condition, who can run it, are they available, union considerations, location of personnel, transportation of personnel, lodging required, who is going to do MMS, who is taking asphalt samples, etc. **To ensure a smooth operation, delegate responsibility for major task areas to key personnel.**

Activity 330 (Allow 2-4 wks. to start of project.)

DEVELOP TRAFFIC CONTROL PLAN

- ? ***Refer to Maintenance Work Zone Guidelines***
- ? ***Montana Supplement***
- ? ***MUTCD***
- ? ***District Traffic Engineer***
- ? ***Piloting***
- ? ***ADT***
- ? ***Intersections***
- ? ***Length of Project***
- ? ***Construction Program***
- ? ***Order Reflective Tabs From Stores***

Safety on the job, smooth flow of traffic and liability are all-important to the success of the project. Management should include the District Traffic Engineer in a meeting to discuss the traffic control plan for the project. Reference the Montana supplement "Guidelines for Work Zone Safety" and Chapter 6 of the MUTCD (Manual of Uniform Traffic Control Devices). Identify who will be responsible for the work zone, and communicate your plans both verbally and in writing. Document your plans and include inspections of the work zone in the Superintendent's or Field Supervisor's diary. Include your project plans in the construction program notification that goes out to the public.

Allow approximately one month to order your reflective tabs for the project.

Activity 340 (Allow 2 wks. to start of project.)

ASSIGN PROJECT DUTIES AND RESPONSIBILITIES

- ***Planning***
- ***Scheduling***
- ***Training***
- ***Transportation***

Personnel need to know as soon as possible what their roles and responsibilities for the project will be. There may be new people that have questions about the process, or there may be training that needs to be addressed, such as what is expected of truck drivers, roller operators, etc.

Activity 350 (Allow 2 wks. to start of project.)

PLACE POST-MOUNTED ADVANCE WARNING SIGNS

- ***Loose Gravel***
- ***Speed Limit 35***

The use of post-mounted Loose Gravel and Speed Limit 35 signs be placed at set intervals (2 miles) along the project should be considered. Installation of these signs can be anytime prior to the start of the project, however, signs need to be covered until the start of the project.

Portable setups shall still be required in those work zone areas, where the work is being performed.

Activity 360 (Allow 2 wks. to start of project.)

MAKE TRANSPORTATION AND LODGING ACCOMODATIONS

- ***Determine Who Needs Lodging***
- ***Determine How to Get Personnel to Project***

Most projects will require you to bring personnel from different sections to man the project. In those cases, you need to look at the cost of overtime verses providing personnel with per diem.

Another issue, is how to get personnel to and from the project site. This becomes a bigger issue when trucks are planned to be left at the project site overnight.

Activity 370 (Allow 2 wks. to start of project.)

CHECK RWIS WEATHER INFORMATION

- ***Check 2 Weeks Prior to Project***
- ***Check 1 Week Prior to Project***
- ***Check Day Before***

You should check Remote Weather Information Systems (RWIS) or other weather information beginning about two weeks prior to the start of the project. You should start checking the weather information more frequently the closer you get to the start of the project. This becomes even more important if the weather is somewhat unsettled. Chip sealing in poor weather conditions could result in a **failed** chip seal! **See Chapter 4 on the critical RWIS information for chip seals and how weather can effect the success of your project.**

MDT specifications recommend chip seals can only be done between May 1 and August 31. Any exceptions will be handled on a case-by-case basis by the Division Administrator.

Activity 380 (Allow 2 wks. to start of project.)

CONTACT INFORMATIONAL SERVICES

- ***Type of Project***
- ***Location of Project***
- ***Date of Project***
- ***Special Considerations***

The Division Construction Program should be notified the week prior to the start of the project. They will notify the radio stations and newspapers in the area of the project, locations, and the dates. This information will be passed on to Public Affairs for statewide distribution. You should note to them that this project is weather-dependent.

Activity 390 (Allow 2 wks. to start of project.)

CALIBRATE CHIP SPREADER

- ***Extensive Calibration Prior to Beginning of Season***
- ***Different Materials – 4A & 5A***
- ***Prior to Project***
- ***See Chapter 4***

We recommend that you do an extensive calibration of the chip spreader prior to the beginning of the chip seal season. You should determine the following information: 1) application rates at various speeds and gears, 2) application rates of different material types 4A and 5A, and 3) moisture of chips can vary your application rates slightly.

If you do an extensive calibration prior to the season. This will provide a good starting point and minor adjustments can be made as the project progresses.

There are a couple of different methods to use in calibrating your chipper:

1) Place a square yard box/tarp with 1" sides and spread chips over the top; then weigh the material in the box or tarp.
2) Weigh a truck load of chips; measure the distance the truckload of chips cover; you can then calculate the application rate (distance (ft) x width (ft) / 9 = sq. yds. Total # lbs/ sq. Yds = application rate) **See Chapter 4 on Calibration Considerations**.

Activity 400 (Allow 2 wks. to start of project.)

SET UP COST CENTER NUMBER

- ***Beginning and Ending Milepost***
- ***Date***
- ***Activity Number (1106)***

Prior to the start of the project, the MMS cost center number for the project needs to be established. The key information needed is the beginning and ending mileposts, date, and the activity number for the chip seal (1106).

NOTE: For tracking purposes, the MMS cost center number will be required on all samples taken for the project.

Activity 410 (Allow 2 wks. to start of project.)

MOW AND SWEEP PROJECT

- ***Mow***
- ***Sweep***
- ***Availability***
- ***Quality***

Mowing the right-of-way will help clearly define the pavement edge and generally improve working conditions for the project. In some areas, rattlesnakes are a consideration, and mowing helps see them. An additional consideration is the tenderness of the surface after the chip seal. A mower making sharp turns around delineators could tear up the surface on a hot day a month after the chip job. Sweep all grass and dirt from the surface. You may need to come back prior to the start for additional sweeping, if necessary. Allowing two weeks will give you some time in case of mower breakdown. **Have a broom on hand the day before you start in case mud is tracked on the surface or some other unforeseen event, like moving cattle! A clean surface is necessary for a successful project**.

Activity 420 (Allow 2 wks. to start of project.)

OBTAIN SAMPLE BOTTLES AND TAGS

- ***Determine Number of Loads***
- ***Determine Number of Bottles and Tags***
- ***Order Additional Bottles and Tags, if necessary***

You will need to make sure that you have an adequate number of sample bottles and sample tags. Remember that every load of asphalt needs to have two samples taken. You can determine how many sample bottles are needed once you determine how many loads of asphalt you plan on. Have the truck driver take a sample in the presence of MDT personnel. Make sure the Project Cost Center number is included on all sample tags.

Activity 430 **(Allow 1 wk. to start of project.)**

GATHER AND CHECK PORTABLE SIGNS AND RADIOS

- ***Check Traffic Control Plan***
- ***Determine Signs Needed***
- ***Gather and Check Signs***
- ***Place All Signs in One Location***
- ***Locate and Charge Up Hand-Held Radios***

Gathering and checking the portable signs prior to the start of the project may eliminate any mix-ups. Check the traffic control plan and/or MUTCD Manual for the appropriate signs. All signs should be in good condition. The use of hand-held radios can also be beneficial for traffic control purposes. If you plan on using radios, ensure that they are in working order prior to the start of the project. A radio on the chip spreader can be beneficial. **See Chapter 5 for appropriate signs and quantities**.

Activity 440 **(Allow 1 wk. to start of project.)**

PRECONSTRUCTION MEETING

- ***Establish Firm Start Date***
- ***Reaffirm Major Duties and Responsibilities***
- ***Reaffirm Construction Procedures***
- ***Discuss Traffic Control Plan***

It is recommended that a preconstruction meeting be held prior to the start of the project. All key personnel who will have major project responsibilities (Activity 340), should attend the meeting. Construction procedures and expectations should be established so everyone understands who is responsible, what is expected, when the project will be done, and how the project will be done. This is the time to answer any 'why' questions.

Activity 450 **(Allow 2-4 days to start of project.)**

HAUL EQUIPMENT TO PROJECT

- ***Chip Spreader***
- ***Rollers***
- ***Trucks***
- ***Loaders***
- ***Sweepers***
- ***Flush Truck***

You will need to make arrangements to park equipment prior to the start of the job. Communicate to everyone which end of the job will be the start and where to park equipment when it's hauled to the job. Hauling equipment to the job will probably involve a lowboy tractor/trailer and a tilt top trailer or two. Make sure the lowboy and tilt tops are in good shape and ready for work. Pilot wide loads when necessary. Build temporary ramps for off-loading where necessary. Some equipment will be taken to the job site the day the project starts but some slow or cumbersome equipment needs to arrive early.

Activity 460 **(Allow 2-4 days to start of project.)**

MAKE ARRANGEMENTS WITH PAINT STRIPE CREW

- ***When***
- ***Quantities***

The reflective tabs will suffice to mark the centerline until the project is swept. But immediately after sweeping, paint stripes need to be applied. Paint crew needs to go out and ensure that stop/start of passing zone markers are up prior to the start of the project. The quantity of paint will depend on whether or not the project is painted in both directions (double application). We highly recommend painting the centerline prior to a weekend, if possible.

Activity 470 **(Allow 1-4 days to start of project.)**

SWEEP PROJECT SURFACE

- ***Adhesion***
- ***Availability***

A clean surface is necessary for the asphalt to adhere to the pavement. Dirt, grass, loose material or tracked mud from approaches needs to be removed. Sometimes something will happen the night before the project starts and a broom is required on a moment's notice.

Activity 480 (Allow 1-2 days to start of project.)

WET CHIP STOCKPILES

- ***Type of Cover Material***
- ***Type of Asphalt***
- ***Staged Stockpiles***
- ***See Chapter 2***

5A cover material has more fine aggregate in it and will hold moisture longer. 5A is also typically used with high float emulsions.

4A cover material has fewer fines and will drain quickly. It is important to wet 4A chips used with rapid sets frequently and thoroughly.

Wet the staged stockpiles in order of their use. The water truck may be one jump ahead of the project as it progresses.

NOTE: If you see water running out of the haul trucks, the chips are too wet.

See Chapter 2 on Aggregate Considerations.

Activity 490 (Allow 1-2 days to start of project.)

CHECK WITH KEY PERSONNEL

- ***MMS and Sampling***
- ***Equipment***
- ***Traffic Control***
- ***Media***

This is the time for a last-minute check to make sure everything is ready. Solve any problems that may have become evident.

Make sure the media is aware of the project dates, locations and detours or options to avoid the project. Activity - 380 had you put the chip seal project on the construction program that is communicated to the public. Reducing the amount of traffic in the project area will: improve safety, improve quality of the chip seal and reduce inconvenience and potential for tort liability claims.

Activity 500 **(Can be done day before start of project.)**

PLACE REFLECTIVE TABS ON THE CENTERLINE

- ***Quantity***
- ***Spacing***
- ***Placement***

Reflective tabs with transparent covers are placed on the centerline ahead of the chip seal to mark the centerline for repainting and to provide temporary delineation for drivers. Stores in your Division Headquarters provides the tabs. Order your tabs about a month before you need them. See Activity - 410

A common spacing is 100 feet between tabs, and more frequent on corners. Knowing your spacing will give you the quantity you'll need for the job. Place an additional tab next to the centerline tab to mark the start and end of a solid line. Continue the double tabs as long as the solid line is present. The tabs can be installed before the project starts.

Activity 510 **(24-Hour Notice)**

ORDER ASPHALT FOR PROJECT

- ***When***
- ***Where***
- ***Distributor***
- ***Quantity***
- ***See Chapter 2***

Ordering and reordering needs to be done by 3:00 p.m. one working day prior to delivery. You need to tell the refinery how much asphalt you need, what type of asphalt and where is it to be delivered (route and milepost). You also need to tell them how many distributors, if any, you will need. You need to communicate your asphalt and distributor needs to the refinery at least a month prior to this time. This is a confirmation and commitment to start of the job.

A 24-hour notice is required by the refinery for cancellation to avoid possible re-stocking fees.

Activity 520 (Day of project.)

SET UP TRAFFIC CONTROL AND START PILOTING PROJECT

- ***Check Traffic Control Plan***
- ***Check Work Zone Safety Guide***
- ***Set Up Traffic Control Signs***
- ***Uncover Post-Mounted Signs***
- ***Start Flagging Operations***
- ***Start Piloting Project***

Check the traffic control plan (Activity - 320) and the Department's work zone safety guide if there are any questions on the signs, spacing, or flagger operations. Traffic control and flagger operations must be in place prior to having any equipment on the roadway or any chip seal operations in progress. If post-mounted signs are being used, they should be uncovered, and any permanent signs that conflict with any temporary signs must be covered. Radio communications between the piloting and flagger operations is highly recommended. It is recommended that the flagger and piloting operations switch off at given time intervals. Pilot vehicles must keep their speed under 25 mph and should avoid using the same wheelpaths whenever possible.

Activity 530 (Day of project.)

CHECK MAT AND AIR TEMPERATURE

- ***Check Mat Temperature***
- ***Check Air Temperature***
- ***MDT Specifications***
- ***See Chapter 4***

The mat temperature must be 65 degrees and rising prior to the start of the chip sealing. The reason for checking air temperature is it will give you an idea how fast the mat temperature is rising or falling. It will also give you an idea how fast the emulsion will break. **MDT specifications recommend chip seals can only be done between May 1 and August 31. The Division Administrator will handle any exceptions on a case-by-case basis.**

See Chapter 4 on temperature considerations during chip seal operations.

Activity 540 (Day of Project.)

LOAD TRUCKS

- ***Last-Minute Truck Inspection***
- ***Last-Minute Loader Instructions***
- ***Last-Minute Truck Instructions***
- ***Load Trucks With Chips***

Prior to loading the trucks with chips, the driver of each truck should do a last-minute inspection of his truck to ensure the truck is ready. Items to look for are: is the chip bar in place, are hydraulic connections covered, do air cans have plugs, and is top light working. This is also a good time to provide the truck and loader operators any last-minute instructions. Loaded trucks should try and stay off the fresh chip, if possible, and avoid turning around on the fresh chips.

Activity 550 (Day of Project.)

LOAD DISTRIBUTOR AND GET ASPHALT SAMPLES

- ***Get Asphalt Samples***
- ***Check Asphalt Temperature***
- ***Load the Distributor***
- ***Check Total Gallons in Truck***
- ***Check and Sign Bill of Lading***
- ***Establish Communication Link Between Distributor and Chip Spreader***

Each load must have two asphalt samples taken from it. The samples are to be taken by the truck driver, MDT is not to take the samples. Before using any asphalt, check the temperature to ensure it falls within the temperature specifications. If it falls outside of the temperature specifications, reject the load. Check the total gallons on each truck and keep a running total so you can make any ordering adjustments each day. This is also a good time to establish how you want the distributor and chip spreader to communicate, outline the asphalt application rate and how far in front of the chip spreader you want the distributor. **Make sure, after you have checked and signed the bill of lading, to keep a copy. Keep the copy with a filled out form.**

Activity 560 (Day of Project.)

REPLACE MISSING REFLECTIVE TABS

- ***Ensure Traffic Control is in Operation***
- ***Replace Missing Tabs***

Before replacing any missing reflective tabs be sure the traffic control and flagging operations are operating. Some Divisions prefer to place their reflective tabs at this time; this eliminates tabs from being lost and the need to replace those lost.

Activity 570 (Day of Project.)

MOVE EQUIPMENT TO START OF PROJECT

- ***Move Chip Spreader***
- ***Move Roller***

Be sure that the traffic control and flagger operations are in operation prior to moving equipment to the start of the project. As soon as the chip spreader is in place, have all other equipment line up.

Activity 580 (Day of Project.)

1000-FOOT TEST SECTION

- ***Get Equipment Lined Up***
- ***Set Up Guidelines for Distributor***
- ***Set Up Guidelines for Chip Spreader***
- ***Shoot 1000 Feet of Asphalt***
- ***Check Asphalt Uniformity***
- ***Check Asphalt Application Rate***
- ***Apply Chips and Roll***
- ***Check Chip Embedment***
- ***See Chapter 3***

Before you start your full chip seal production, we recommend that you do a 1000-foot test section to ensure everything is working properly. Reaffirm the guidelines for the distributor and chip spreader, application rates, width, meet line considerations, how soon to apply chips, and how far in front you want the distributor. While the distributor is shooting off the 1000 feet, check the asphalt uniformity. **See Chapter 3 on asphalt uniformity, overlap, bar height, etc.** When the distributor has completed the 1000 feet, check the asphalt application rate.

Activity 590 (Day of Project.)

ADJUST APPLICATION RATES AND MAKE OTHER ADJUSTMENTS

- ***Adjust Asphalt Application Rate, If Necessary***
- ***Adjust Chip Application Rate, If Necessary***
- ***Make Any Spray Bar Adjustments***
- ***Make Any Chip Spreader Adjustments***
- ***See Chapter 3***

While the chip spreader is spreading the chips on the test section, check the salt and pepper appearance of the chips. After rolling the chips, check the chip imbedment. There should be between 50 and 70 percent imbedment. If your imbedment is less than 50 percent, check your asphalt application rate and make adjustment. If the existing surface is dry, oxidized and cracked, you may want to increase your asphalt application rate slightly. During and after the 1000-foot test section, this is your opportunity to make adjustments to the distributor, chip spreader or application rates. **See Chapter 3 on distributor and/or chip spreader adjustments.**

Activity 600 (Day of Project.)

START SHOOTING ASPHALT

- ***Start Shooting Asphalt***
- ***Keep Constant Distance Between Distributor and Chip Spreader***
- ***See Chapter 2***

After you have made any adjustments start shooting the asphalt. Try to maintain a constant distance between the chip spreader and the distributor at all times. This distance will depend on the type of asphalt being used, and weather. For example, when using a CRS-2, it is critical that you be no more than 200 feet behind the distributor with the chip spreader; closer is preferable.

See Chapter 2 on asphalt and aggregate considerations.

Activity 610 (Day of Project.)

START APPLYING CHIPS

- ***Start Applying Chips Based on Type of Asphalt***
- ***Watch for Plugups or Streaks***
- ***Watch for Distributor Problems***
- ***Timing is Critical – Don't Wait Too Long***

Once the asphalt has been shot, start applying chips, based on the type of asphalt being used. It is essential, that if a CRS-2 is being used, you apply the chips as soon as possible. We recommend that you apply chips immediately to polymer and latex modified emulsions. **If you apply the chips too late you will not get the imbedment or the chip adhesion. In other words, you will probably lose the chips.**

You need to keep watch for plugups in the chip spreader creating streaks in the chips. In addition, watch the distributor for problems and notify the distributor operator immediately if you see any problems.

Activity 620 (Day of Project.)

START ROLLING THE CHIPS

- ***Start Rolling the Chips Immediately***
- ***Stagger Wheelpath When Trucks Are Backing Up***
- ***Roll Meet Line as Soon as Possible***
- ***Keep Rollers Up With Chip Spreader and Trucks. DON'T GET TOO FAR BEHIND.***
- ***See Chapter 4***

Rolling of the chips should be done with a rubber tire roller. Be sure that the tire pressure is the same in all of the tires. Start rolling the chips immediately with special attention being paid to the meet line. It is critical that the trucks stagger their wheelpaths when backing up. Rollers should be operated at slow speeds, 4 to 6 mph, so the chips are not displaced. The number of rollers required for a project depends on the operation. It takes 2 to 4 roller passes to set the chips. Steel wheel roller can be used as a last resort, but special attention must be given to ensure the chips are not being fractured. Rolling is an essential part of a successful chip seal. **See Chapter 4 on roller considerations.**

Activity 630 (Day of Project.)

MONITOR THE PROJECT

- ***Monitor the Asphalt Application Rate***
- ***Monitor the Chip Application Rate and Check Salt and Pepper Appearance***
- ***Monitor Asphalt Uniformity***
- ***Monitor Chip Embedment***
- ***Monitor Traffic Control and Speeds***

After the chip seal operation is in full swing, you need to occasionally monitor various aspects of the project. We recommend that you monitor every time the distributor starts shooting a new load.

Besides the obvious asphalt and chip items, watch your traffic control and piloting operations. Make sure that the piloting vehicle does not exceed 25 mph.

See Chapter 4 on how to calculate application rates (under calibration procedures).

Activity 640 **(Day of Project.)**

ORDER ASPHALT FOR NEXT DAY

- ***Re-calculate Quantities Needed***
- ***Specify Time, Location, Number of Loads, and Total Gallons***
- ***Order by 3:00 p.m. – Earlier is Preferable***

Before you order asphalt for the next day, keep a running total of gallons used to date and how far you have gone. Then you can recalculate how many gallons you need to complete the project and the number of loads. The same information is required as your original order. Time and location may vary day-to-day; be sure to communicate any changes. **The asphalt contract has a 3:00 p.m. deadline for asphalt orders for next-day delivery.** This allows little time to work out any potential problems with the refinery, so order earlier if possible.

Activity 650 **(Day of Project.)**

END OF THE DAY

- ***Store Equipment***
- ***Service Equipment***
- ***Outline Next Day's Start Time and Location***
- ***Outline Any Changes in Traffic Control and Any Location Moves***
- ***Pull Tab Covers***
- ***Take Asphalt Samples to Division Lab***

At the completion of the day, all equipment should be stored in an off-site location. Any repairs and refueling should be made prior to the next day's starting time. This is a good time to discuss any problems that occurred that day and any changes in the next day's operation. Outline the starting point and time for the next day.

Before going home for the day, have a couple of people remove the covers from the reflective tabs.

Remember to take asphalt samples and paperwork to the Division lab.

Activity 660 (Day of Project.)

FILL OUT PAPERWORK

- ***MMS Paperwork***
- ***Asphalt Sample Paperwork***
- ***Sign Trucker & Distributor Paperwork***
- ***Field Diary***

Make sure you keep up on the daily MMS and asphalt sample paperwork. Also, be sure you sign the trucker and distributor's paperwork, and fill out any additional paperwork related to the refinery. It is important to fill out a daily field diary for the project. Note any changes or problems, such as traffic control changes.

See Chapter 6 for examples of paperwork and forms to be filled out.

Activity 670 (Day of Project.)

PILOT PROJECT

- ***Keep Speeds Under 25 MPH***
- ***Outline How Long to Pilot***
- ***Outline When They Are to Start the Next Day***
- ***Put Up Loose Gravel Signs***
- ***Have Pilot Car Drivers and Flaggers Trade Off***

When the second shift of flaggers and pilot car drivers come on, outline how long you want them to flag and pilot. Stress that they need to keep speeds under 25 mph. If you want the second shift to arrive on the project at a different time the next day, be sure to communicate that information.

Be sure that you have "Loose Gravel" and "No Passing" signs up before going home for the day.

If piloting continues into darkness, make sure the MUTCD (Chapter 6) is referenced for additional compliance and considerations.

Activity 680

IF THE PROJECT IS NOT COMPLETE, RETURN TO ACTIVITY 570 FOR NEXT DAY

Return to Activity 570 for all days following the first day until you complete the project.

Activity 690

SWEEP THE PROJECT

- ***Review Flagger Considerations***
- ***Make Traffic Control Adjustments***
- ***Use Flush Truck to Water Down Area to be Broomed***
- ***Broom the Project Twice***
- ***Wait 24 Hours After Applying Chips Before Brooming***

Before you start brooming a project, make sure that you have made flagger and traffic control adjustments. You will need traffic control signs and a flagger, at a minimum. You may want to pilot the area being swept, especially if you have a high ADT roadway. We highly recommend that you water down the area to be swept prior to brooming; this will help with dust control. We also recommend that you broom the project twice; this will avoid breaking windshields.

Wait 24 hours after applying the chips before you start brooming operations.

Activity 700

FOG SEAL PROJECT

- ***Check Chip Embedment***
- ***Type of Emulsion***
- ***Use Two Lighter Applications***
- ***Make Adjustments***
- ***See Chapter 4.***

You may want to consider fog sealing your chip seal. Fog sealing higher ADT roadways and/or chip seal projects with poor embedment may have some benefits: reduced chip loss after sweeping, reduced windshield breakage, improved traffic marking visibility. However, before deciding to fog seal the project, **check the chip embedment**. If the embedment is more than 80 percent, it is highly recommended that you don't fog seal.

If you decide to fog seal the project, use two (2) lighter applications (.04-.07 gal./sq. yd.) of SS-1 or equivalent emulsion. Remember to cut the emulsion with water (one part water to one part emulsion). Two lighter applications will allow you to make adjustments and prevent creating a flushed pavement surface.

See Chapter 4 on Fog Seal Considerations.

Activity 710

REMOVE ALL TRAFFIC CONTROL SIGNS FROM PROJECT

- ***Temporary Speed Limit***
- ***Loose Gravel***
- ***Uncover Permanent Speed Limit Sign***

As soon as possible after the chip seal has been swept, the project needs to be striped. We highly recommend that at least the centerline needs to be striped on high ADT roadways prior to the weekend, if at all possible. Before starting to stripe the project, make sure you check to see if all tab covers have been removed and you know where all passing zone markers are. Make sure the TMA is available.

Activity 720

STRIPE THE PROJECT

- ***Check Tabs and Passing Zone Markers***
- ***Establish Application Rates***
- ***Establish Number of Passes***
- ***Check to Ensure TMA is Available***
- ***Stripe ASAP and Try to Get Centerline Striped Prior to the Weekend, Especially on High ADT Roadways***

After the project has been swept and striped, all temporary signs need to be removed from the project. All permanent signs you covered during the project need to be uncovered.

Activity 730

FILL OUT PROJECT COMPLETION PAPERWORK

- ***MMMS***
- ***PMS***
- ***Refinery Paperwork***
- ***Field Diary***

Upon completion of the project, there will be paperwork to fill out for the project. MMS paper work needs to be filled out, such as asphalt and aggregate used. Complete the pavement management system form for the project and send it in to the Maintenance Division. You will also need to complete the paperwork so the refinery gets paid**.**

CHAPTER 2

MATERIALS CONSIDERATIONS

CHAPTER 2 - MATERIALS CONSIDERATIONS

ASPHALT CONSIDERATIONS

There are three basic types of asphalt used in construction and maintenance:

1. Asphalt Cement
2. Cutback Asphalt
3. Emulsified Asphalt

ASPHALT CEMENT

Asphalt Cement, or AC, is asphalt in its purest form. There are different grades of AC, based on the penetration or viscosity of the asphalt. An example is a PG 64-22 (performance grade). AC's are primarily used for the production of plant mix (hot).

AC's have the advantages of:

- being made of pure asphalt because it does not require cutter stock,
- requiring little or no curing period. As soon as they have cooled, they obtain their full strength (holding power).

The AC's have several disadvantages:

- They require high application temperatures (250° to 450° F) to make them fluid enough to handle well.
- The cover stone must be applied rapidly to the asphalt cement before it becomes less fluid (too stiff). If there is a delay, it is difficult to completely embed the rock into the asphalt. Heating the cover stone is a means of improving the imbedment. However, the disadvantages of this are heating costs and the generation of fines.
- Working at these high application temperatures, handling the asphalt cement becomes hazardous.
- It may be difficult to maintain the application temperature without reheating.
- Typically not used for seal and covers.

CUTBACK ASPHALT

Cutback asphalt is asphalt cement which had been thinned or liquefied ("cut back") by blending with petroleum solvents (also called "diluents"). This makes the asphalt more workable and easier to spray.

Upon exposure to the atmosphere, the solvents evaporate, leaving the pure asphalt cement (AC) to harden. The type of solvent used determines how quickly the asphalt hardens, since some solvents evaporate much quicker than others.

With the growing concern for air quality in recent years, cutback asphalts are not used as widely as they once were. Cutbacks can be used when other types of asphalt are not suitable; for example, stockpile storage.

- The hardness of the asphalt selected is based on the temperatures the asphalt will be subjected to on the roadway.
- The type of solvent controls the curing time of the cutback and thus when the cutback will obtain its ultimate strength. The Rapid Curing (RC) cutbacks with naphtha (gasoline) cutter cure more rapidly than the Medium Curing (MC) cutbacks with the kerosene cutter.
- The amount of cutter affects the viscosity of the cutback asphalt. The higher the cutter content, the lower the viscosity or the more fluid it will be.

Cutback asphalt has several advantages:

- They are fluid at lower application temperatures (50° to 250°F).
- They remain fluid for a longer period after they have been applied to the road, which permits some latitude between their distribution and the rock application.
- Some of the cutter will remain in the cutback for an extended period. This allows a cutback seal to remain flexible to conform to some movement in the underlying pavement and base. Cutbacks have self-healing characteristics with minimal cracking.
- Cutback can tolerate some fines and dust in the cover aggregate. The kerosene cutter is more tolerant than the naphtha to these fines.
- Mixes can be made with unheated aggregates and some cutbacks, such as MC 800.

The disadvantages of cutbacks are as follows:

- Cutbacks do not obtain their ultimate strength until a good part of the solvent has escaped (evaporated). During the "curing period," the rock can be displaced under heavier traffic, particularly in warm weather. During this same period, early rain can float the cutback to the top of the rock and can be tracked away under traffic. The type of cutter solvent affects the "curing period."
- There is a potential fire hazard using cutbacks that contain petroleum solvents.
- Air pollution is a concern as the solvent evaporates into the atmosphere.
- Excessive moisture on either the pavement to be sealed or the cover rock can hinder good adhesion with a cutback.

EMULSIFIED ASPHALT

Emulsified asphalt (also called "emulsions") is asphalt cement (AC) combined with water to make the asphalt more liquefied. Since asphalt cement and water do not naturally mix, a small amount of emulsifying agent is used.

This mixture is further categorized as either anionic or cationic, depending upon the emulsifying agent used. The important point about this difference is that cationic and anionic emulsions MUST NEVER BE MIXED.

Upon exposure to the air, the water and emulsifying agent evaporate, leaving pure asphalt cement (AC) which hardens to bind the aggregate in place. The point when the water evaporates is known as when the "emulsion breaks." This is visible on the roadway when the asphalt's color suddenly turns from a muddy brown to a clear black. Emulsions are most commonly used for chip seal projects.

- Emulsions are made with different grades (hardness) of asphalt for varying climatic conditions.
- Emulsions are manufactured with several different formulas for use in the construction of seals or mixes.
- Varying amounts of cutter are used to alter the emulsion for specific applications.
- Grades of emulsions are manufactured to have different viscosities and curing times to meet specific construction needs.

Asphalt emulsions have the following advantages:

- Emulsions are stored and handled at cooler temperatures. See tables in Appendix B for appropriate charts for storage and application temperatures.
- Mixes can be made with damp and cool aggregates.
- Most emulsions contain an anti-strip additive.
- The seal coating grades of CRS-2 and CMS-2 cure more rapidly than the cutbacks under most conditions.
- The water phases make them less of a fire hazard to use.
- Lower handling temperature results in less burn hazard.
- The emulsions can be manufactured with a small percentage of solvent. The solvent and content can:
  – affect the curing characteristics of the emulsion,
  – affect the flexibility and self-healing characteristics of the seal coat,
  – permit the use of cover aggregates containing fines.
- The grades of CSS-1, CMS-2, and high float (HF) emulsions can be diluted with most waters to change their viscosity and asphalt content.

The asphalt emulsions have several disadvantages:

- If they are overheated (boiled) or frozen, they can break and become unusable.
- Emulsions are not compatible with cutbacks or asphalt cements.
- Anionic and cationic emulsions are not compatible.
- Are susceptible to rain and environmental conditions until cured.

Each grade of asphalt emulsion is designed for specific uses.

Rapid-Setting Emulsions: The rapid-setting grades are designed to react quickly with aggregate and revert from the emulsion state to asphalt. The RS grades produce a relatively heavy film. They are used primarily for spray applications, such as aggregate (chip) seals. The RS-2 and CRS-2 grades have high viscosities to prevent runoff.

Medium-Setting Emulsions: The medium-setting grades are designed for mixing with plus ¼ coarse aggregate. Because these grades do not break immediately upon contact with aggregate, mixes using them remain workable for a few minutes. The CMS grades have high viscosities to prevent runoff.

High floats are another type of medium-setting asphalt emulsion, and are anionic in nature. The major difference between this emulsion and the conventional medium-setting type is the high float characteristic, measured on the asphalt residue by the Float Test. It reportedly gives better aggregate coating and asphalt retention under extreme temperature conditions. While regular asphalts have a tendency to flow, or migrate, at about 140°F (60°C), the high float residues are designed to stay in place up to about 160°F (71°C). Therefore, high float residues are less susceptible to changes in temperature.

Slow-Setting Emulsions: The slow-setting grades are designed for maximum mixing stability. They are used with high fines content, dense-graded aggregates. All slow-setting grades have low viscosities that can be further reduced by adding water. These grades, when diluted, can also be used for tack coats, fog seals, and dust control. The SS type of emulsion depends entirely upon evaporation of the water for coalescence of the asphalt particles.

ADDITIVES

Another compound may be added to the basic asphalt type to produce desirable properties or characteristics not abundant in the basic asphalt. For instance, latex and polymers have been successfully combined with asphalt cement and emulsions, and are commonly used in seal coats, such as CRS-2LM, CRS-2P or HF 100P.

EXTENDED STORAGE AND HEATING CONSIDERATIONS

If the asphalt must be stored for extended periods, follow these precautions:

With Emulsions:

- A lower storage temperature is desirable. See table for appropriate emulsion storage temperatures in Appendix B.
- With extended storage, a skin will form on top of the emulsion where it is in contact with the air. Floating a layer of solvent, such as a naphtha or kerone, on the surface of the stored emulsion will prevent or reduce the formation of skin.
- Occasional circulation is helpful.
- It is desirable to fill and load out of the storage tank from the bottom.
- If the storage tank is filled through the top, any skin that may have formed can break up into small chunks of asphalt that can plug pumps and snivies.
- Extended storage of emulsified asphalts through an entire winter will cause the asphalt and water to separate. The emulsifying agent losing its charge causes this. This will cause a tremendous mess, and the asphalt will no longer be usable.

- Repeated heating of emulsions will also cause the water to evaporate leaving almost pure asphalt cement. The same is true of repeated pumping of emulsions - since the viscosity tend to be quite unstable.
- **We recommend that you <u>NOT</u> store emulsion over the winter.**

CO-MINGLING OF ASPHALTS

Co-mingling of grades of asphalt is a practical necessity; however, there are certain limitations:

- Emulsions are not compatible with cutbacks or AC grades.
- Even small amounts of cutback or AC grades in an emulsion will result in slugs of asphalt, which can cause pumping problems and plugged snivies.
- If emulsion remains in a tank, putting hot cutbacks or paving grades in on top can cause the mixture to foam and boil over because of the rapid expansion of the retained water.
- Generally, cationic (+) and anionic (-) emulsions are not compatible. Their mixture will cause the emulsion to break and become unusable.
- To prepare tanks, tar pots, or equipment for alternate uses with emulsions, paving grades, or cutbacks, they should be drained and thoroughly flushed with a petroleum solvent. The "flushing" solvent should be drained before refilling the tank.

EMULSION DO'S AND DON'TS

DO when heating emulsified asphalt agitate it to eliminate or reduce skin formation.

DO store as you would fluid water – between 50°F (10°C) and 185° F (85°C), depending on the use.

DO store at the temperature specified for the particular grade. For example, the higher viscosity rapid-set spray grades are stored at 125°F to 185°F (50°C to 85°C) since they are usually applied in this temperature range. The lower viscosity grades are stored at lower temperatures.

DO use a mild heating method to apply heat to the pump packing or casing to free a seized pump. Discourage the use of propane torches.

DO warm the pump to about 150°F (65°C) to ease start-up.

DO before diluting grades of emulsified asphalt, check the compatibility of the water with the emulsion by testing in a flask.

DO if possible use warm water for diluting and always add the water slowly to the emulsion (not the emulsion to the water).

DO avoid repeated pumping and recycling, if possible, as the viscosity may drop and air may become entrained, causing the emulsion to be unstable.

DO guard against mixing different classes, types, and grades of emulsified asphalt in storage tanks, transports, and distributors. For example, if cationic and anionic emulsified asphalts are mixed, the blend will break and separate into water and coagulated asphalt that will be difficult to remove.

DO pump from the bottom of the tank to minimize contamination from skinning that may have formed.

DON'T let the emulsion freeze. This breaks the emulsion, separating the asphalt from the water. The result will be two layers in the tank, neither suited for the intended use, and the tank will be difficult to clean.

DON'T permit the emulsified asphalt to be heated above 185°F (85°C). Elevated temperatures evaporate the water, resulting in an increase in viscosity and an asphalt layer in the tank. The materials can no longer be used as intended and it will be difficult to empty the tank.

DON'T apply severe heat to pump packing glands or pump casings. The pump may be damaged and the asphalt may become even harder.

DON'T dilute rapid-setting grades of emulsified asphalt with water. Medium and slow setting grades may be diluted, but always add water slowly to the asphalt emulsion. Never add the asphalt emulsion to a tank of water when diluting.

DON'T re-circulate emulsified asphalts for too many cycles. They tend to lose viscosity when subjected to pumping. Also, air bubbles may become entrained which would render the emulsion unstable.

DON'T load emulsified asphalt into storage tanks, tank cars, tank transports, or distributors containing remains of incompatible materials.

AGGREGATE CONSIDERATIONS

Aggregate is any hard, inert material used in graduated-size particles or fragments as a part of the seal coat. It is the aggregate that comes in contact with vehicle tires and provides the skid-resistant surface. For this reason, the choice of the correct aggregate is as important as the choice of the best asphalt for the job.

For use in seal coats, there are numerous characteristics and properties the aggregate should possess. Maintenance has two acceptable gradations for chips (4A or 5A) found in the Standard Specification Manual.

Before selecting one type of asphalt over another, or changing the aggregate source, you should consider some important factors:

- Type of Roadway - Is it a two-lane or an interstate, urban or rural? Is the need for good skid resistance the most important factor?

- Volume of Traffic - Just because it is a two-lane roadway does not mean this is not high ADT roadway.

- Weather Conditions - How important is skid resistance?

- Availability of Good Aggregate - How far do you have to go to get good chips?

- Cost - Before deciding on one aggregate over another or not to use an aggregate, consider all alternatives and their cost and overall benefit to the project.

The important aggregate characteristics you should look for in a good aggregate chip are:

- Maximum Particle Size
- Overall Gradation
- Particle Shape - The ideal shape of aggregate particles would be cubical or pyramidal. This, of course, is not possible, but the particles should be angular for better skid resistance and for better bonding with the asphalt. Asphalt will stick to an irregular-shaped particle much better than to a round, smooth one.

- Cleanliness - If the aggregate is excessively dirty or dusty, asphalt will not be able to hold the aggregate particles securely in place. The asphalt will stick to the coating of dirt or dust, and as soon as traffic passes over, the aggregate particle will dislodge. The aggregate should also be free of foreign matter such as leaves, grass, sticks, and lumps of clay or dirt. Dirty aggregate and lack of imbedment are primary factors in windshield damage, as aggregate particles are dislodged under traffic. Wetting your stockpile and aggregate will help reduce the effects of dirty or dusty aggregate.

- Toughness of Abrasion - The aggregate must be able to resist abrasion and polishing (wearing away or wearing smooth), as well as degradation (breaking apart). If the aggregate surfaces wear away and become smooth, the skid resistance will be lost. If the particles break apart, the broken pieces will probably dislodge (more windshield damage) and bleeding or flushing will likely result. Check the abrasion/wear results of aggregate from the Materials Bureau. Good wear results are less than 30 percent.

ABSORPTIVE CAPACITY

All aggregates are somewhat porous and will absorb some liquids: water as well as asphalt. This is not always bad, especially when using an emulsion. However, if the aggregate absorbs water through the surface, it will tend to strip the asphalt away from the particle.

ASPHALT ADHESION

An aggregate's asphalt adhesion is its tendency to resist the efforts of water to strip the asphalt away from the rock. The aggregate asphalt adhesion is found in the chip design. **A low adhesion result is a good indication you will lose the chip.** We recommend that you don't use aggregate with an asphalt adhesion of less than 70 percent.

MDT recommends that chip seals utilize either the Grade 4A or 5A chip gradation specification.

Sieve	Percentage by Weight Passing	
Size	Grade 4A	Grade 5A
3/8"	100	100
No.4	0-30	9-50
No. 8	0-15	2-20
No. 200	0-2	2-5

* Wear (abrasion resistance) not exceed 30 percent.

* Grade 4A minimum coarse aggregate fracture on one fractured face of 70 percent and 50 percent for Grade 5A.

AGGREGATE STOCKPILING

It is important for stockpiles to be situated so that they are not contaminated. Extreme care must be taken so that clay and mud do not pose a problem. Stockpiles should not be situated where there is a likelihood that roadway drainage will cause the aggregate to remain excessively wet. Truck access in and out of the stockpile site can create additional problems.

It may be necessary to prepare a stockpile area before the aggregate is placed on it. The site may require leveling with a dozer or motor grader, and the clearing of any debris such as vegetation, rocks, and sticks. When choosing a stockpile site, ensure adequate sight distance is available for everyone's safety.

Long-term storage of stockpiles should be placed in a manner that will minimize (or prevent) segregation and degradation.

Segregation: The separation of the different sized aggregate particles. Segregation would result in one part of the stockpile containing only the coarser particles and another area containing only finer particles. Ideally, samples taken from any area of the stockpile should contain a representative sampling of the complete range of sizes.

Degradation: Degradation means the breaking apart of the aggregate particles. This, of course, would result in a finer gradation of aggregate than desired. Degradation occurs most commonly from improper operation of the front-end loader rather than improperly constructed stockpiles.

WETTING DOWN STOCKPILES

We highly recommend that you water down the stockpile a couple of days prior to the start of the project. Your goal is to achieve a damp chip. Damp chips will help increase chip imbedment in the asphalt by assisting to migrate up the chip using the surface water. **Chips should be visibly damp but not saturated.**

APPLICATION RATE CONSIDERATIONS FOR BOTH ASPHALT AND CHIPS

Numerous factors influence the application rate of asphalt. Among these factors are:

- Traffic Speed and Volume
- Gradation & Size of Aggregate
- Type of Aggregate
- Dryness and Cracking of Old Pavement - Asphalt pavements which are excessively dry or cracked require more asphalt. You will need to make that adjustment on-site. Generally, you can add an additional .02-.03 of a gallon/square yard to dry, cracked pavements to get the proper chip imbedment.
- Type of Asphalt - The type of asphalt used will influence the application rate. Although the end result will generally be the same, the amount applied on the road will vary. If your chip design indicates less than 0.30 gallons per square yard, resubmit an aggregate sample and get a new design. If the second design comes back the same, go ahead and use the design; if not, use the new design. Have your division labs take the aggregate samples. **Good samples are critical to the outcome.**
- Asphalt application rates should be reduced in bleeding or flushing pavements.
- Regardless of the system used to compute the application rate, the percentage of aggregate embedded in the asphalt is the primary concern. It is important to remember that the purpose of the asphalt is to seal the existing surface and to hold the aggregate covering on the road.

The result of too much imbedment is the asphalt will probably bleed or flush to the top of the aggregate. This occurs commonly in hot weather when the asphalt binder expands as the temperature rises. On the other hand, if the aggregate is not imbedded enough, it will tend to dislodge under traffic.

After the chips have been rolled, remove a random sampling of the largest size rocks. You can then determine the percent imbedment of rock in the asphalt. An imbedment of

50 to 70 percent is desirable. If your imbedment is less than 30 percent, consider increasing your asphalt application rate. **However, remember when adjusting your application rate, make small adjustments at a time.** For example, if the design is 0.33 per square yard, don't go up to 0.38; try 0.35 first.

There are several methods to determine amount of cover aggregate:

- The chip seal design should be used unless other factors indicate a change is needed.
- The application rate can be changed, based on experience and salt and pepper appearance.
- The proper rock cover is when 10 percent to 15 percent black (asphalt) can be seen through the newly laid rock (salt and pepper appearance).
- Enough cover aggregate should be spread to prevent pickup under traffic.
- There should not be a surplus of rock on the shoulders after the surface has been broomed and is being used by traffic.
- Too much aggregate will prevent good imbedment for most of the chips, resulting in increased chip loss, broken windshields, and material waste.
- If bleeding does occur, blending 25 to 50 percent hydrated lime with blotting material (sand) can be applied using a sanding unit. This has been used successfully in some areas

CHAPTER 3

EQUIPMENT CONSIDERATIONS

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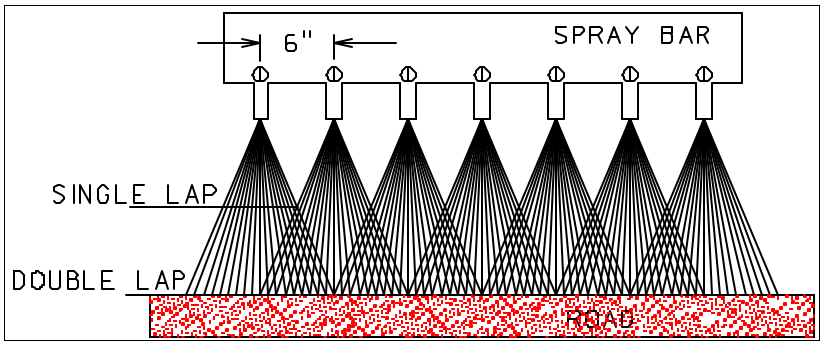
DISTRIBUTOR

Probably the most important piece of equipment, from the standpoint of the chip seal's success, is the asphalt distributor. If the asphalt binder is not applied correctly, the cover aggregate cannot be expected to stay in place under traffic. You can avert almost certain disaster by ensuring that the distributor is carefully inspected and **calibrated**.

It is critical the distributor be properly adjusted and operated to uniformly apply the proper amount of asphalt. The bar and its snivies (nozzles) must be properly set to obtain a uniform shot (application). The snivy size, spacing, and angle in relation to the bar determine the height of the bar.

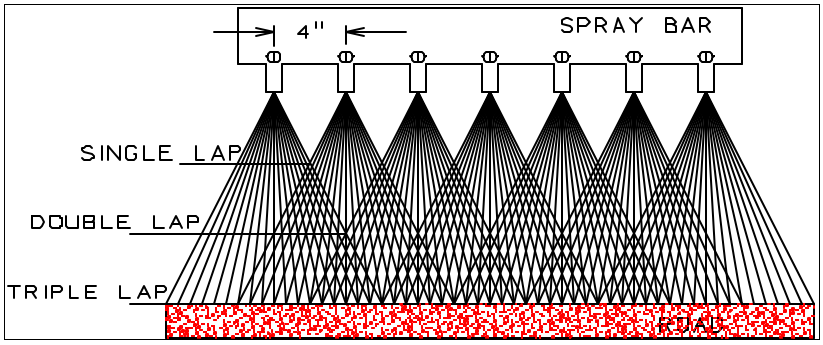
Streaking and drill marks will occur:

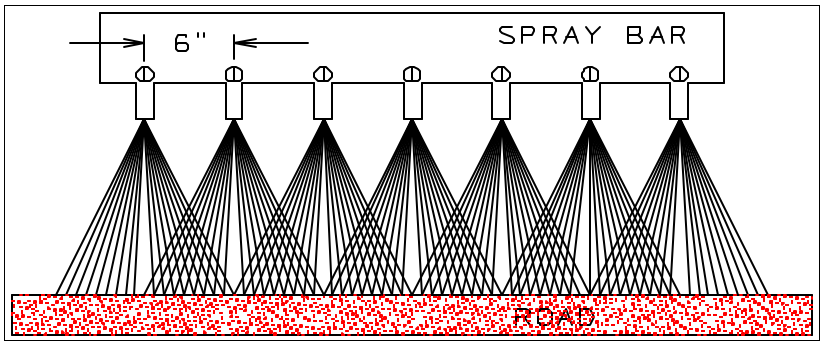
- if the asphalt is too cold;
- when the viscosity of the asphalt is too high (too thick);
- if the snivies are not at the same angle;
- when the bar is too high;
- when the bar is too low.
- When the bar pressure is too high it cuts furrows because the snivies are too small and/or there is too much pump pressure.
- When the bar varies in height from a full to an empty distributor, blocking or locking against the overload springs will reduce or eliminate this variance in height.
- When the bar is too long and/or the snivy openings are too large for the pump capacity, this results in narrow and fluttering fans. Smaller snivies and/or higher pump capacity will correct this.
- If the pump pressure is too low it will create narrower spray fans and fluttering.
- If the distributor tank is allowed to run completely empty, an irregular pattern of misses and fluttering will occur across the bar. For this reason, the shot should be terminated while approximately 100 gallons are left in the distributor.



It is important that the distributor be properly adjusted to uniformly apply the proper amount of asphalt.

The bar and snivies must be properly set to obtain a uniform application. The snivy size, spacing and angle determine the proper bar height.

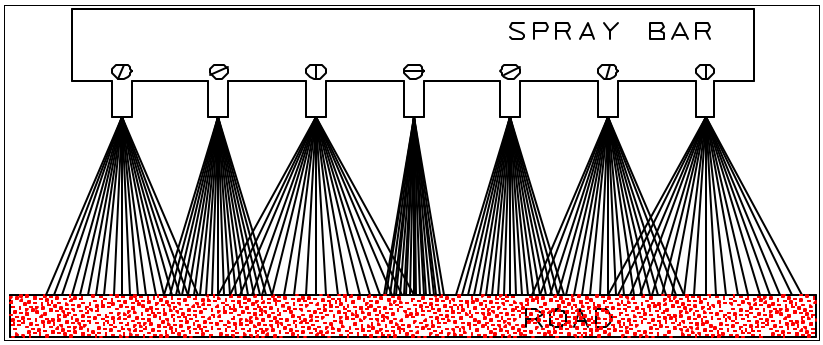




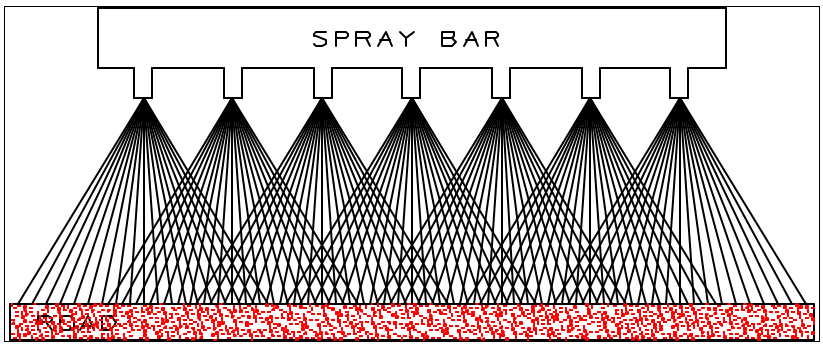
Streaking and drill marks will occur if:

? The asphalt is too cold.

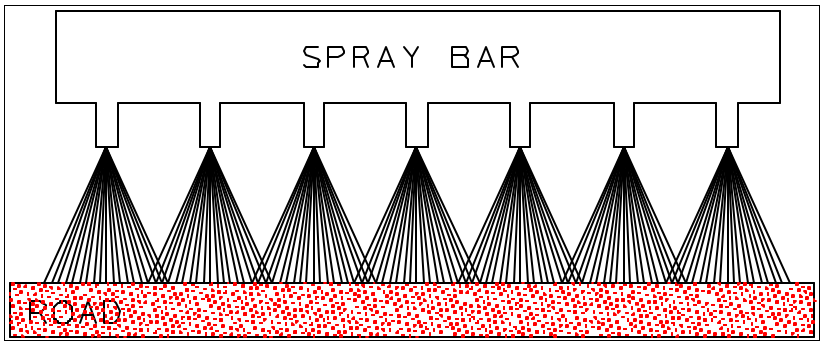
? The viscosity of asphalt is too high.



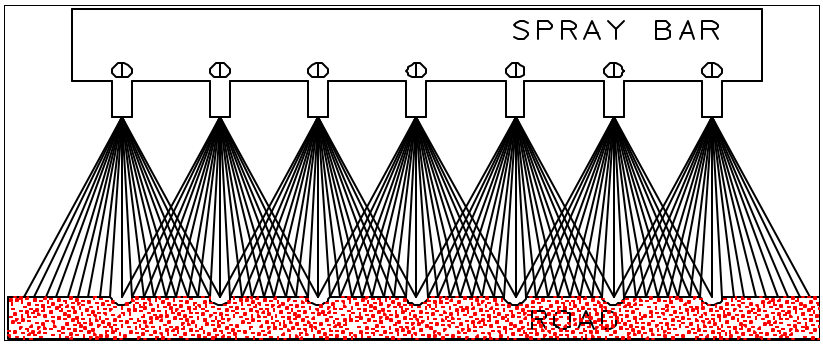
? If the snivies are not all at the same angle.



? When the bar is too high.



? When the bar is too low.



? If the bar pressure is too high. It cuts furrows in the asphalt and there is too much pump pressure.

Proper Bar Height

To determine proper bar height:

- make sure the asphalt is at the proper temperature;
- install the right sized snivies;
- make sure all the snivies are at the proper angle;
- set the proper pump pressure (or output);
- cut off (turn off) the snivies to produce a single lap, every other snivy for 6" spacing and two snivies for every three with 4" spacing.
- If the bar is too low there will be white streaks (areas of no asphalt coverage).
- If the bar is too high, black (double application) streaks will appear.
- Once the perfect single coverage is achieved, turn on the remaining snivies.

Distributor Speed

The distributor operator should adjust his speed based on application rate and chip spreader speed. The operator should always strive to keep a constant distance between the distributor and chip spreader. If the distributor is applying a rapid-set emulsion (CRS-2) or Latex or polymer modified emulsion (CRS-2Lm), the operator should strive to keep a maximum distance of 200 feet in front of the chip spreader. If a high-float emulsion is being applied, the maximum distance the distributor should be ahead of the chip spreader should be based on the breaking rate of the emulsion.

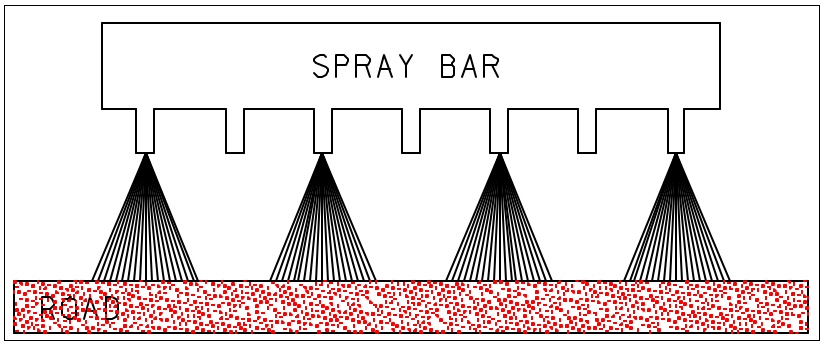
> **Caution:** Remember, when checking the breaking rate of the emulsion, the cooler or damper the area, the slower the breaking rate. You may have shaded and sunny areas on a project. Don't wait for the shaded areas to break; watch the sunny areas. Again, don't let the distributor get more than three to four minutes ahead of the chip spreader.

Distributor Application Temperatures

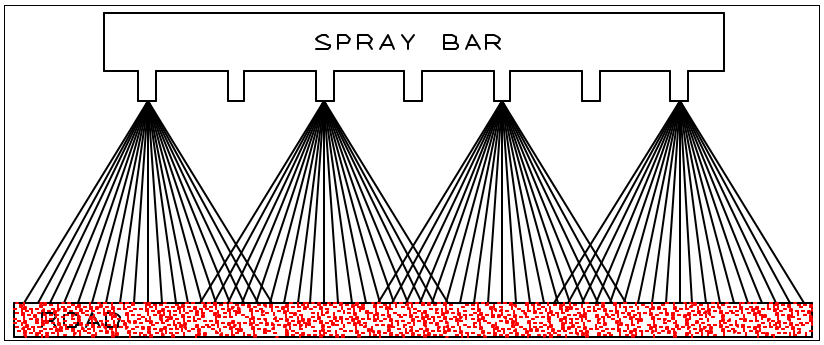
Your spray or distributor application temperature will be based on the type of emulsion being applied. See chart for appropriate application temperatures in Appendix B. Remember, if your emulsion is too cold, asphalt streaking will occur. If the emulsion is too hot, the emulsion is unstable and may break in the distributor.

PROPER BAR HEIGHT

To determine proper bar height:



? If the bar is too low, there will be white streaks (areas of no asphalt coverage)



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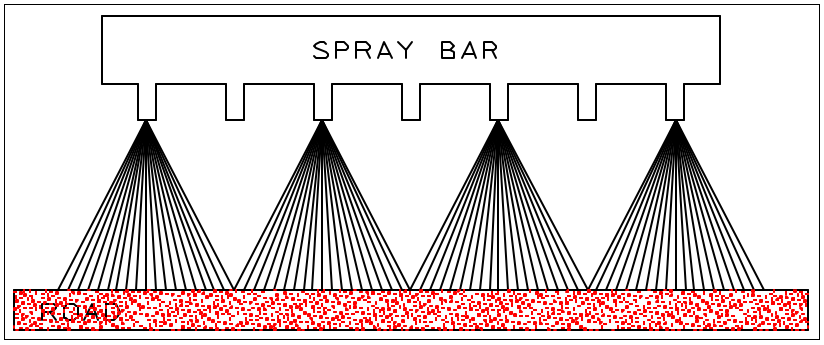


? This is perfect coverage. Then turn on the remaining snivies and shoot.

CHIP SPREADER

Before the distributor begins it's first shot on the project, the aggregate spreader must be in position and ready to begin. In your last-minute equipment check, be certain to check with the spreader operator to make certain his machine is ready. Also, be certain that the individual who controls the aggregate flow and gate adjustment, is present and ready.

There should be one haul truck behind the aggregate spreader, loaded with aggregate with which to fill the spreader. There should be at least two or three more trucks loaded and in line.

As soon as the operator has the spreader in position, the assistant checks all the discharge gates. He makes certain that all the gates needed are open to ensure complete coverage of the asphalt shot. If the discharge hopper is wider than the asphalt, some of the gates on the right-hand side would be closed.

Truck Hookup

When all is ready, the waiting truck backs up to the spreader and stops slightly short of coming in contact with the spreader. This allows the spreader operator to back the spreader into the truck, so that the hitches connect. A spotter should be used to ensure correct connection.

The truck driver then shifts his transmission into neutral to allow the spreader to tow the truck backwards as the aggregate is spread. Upon a signal from the spreader operator or his assistant, the truck driver releases the tailgate latch. He raises the truck bed as he is told and allows the aggregate to fill the receiving hopper. He must remain ready to lower the bed on signal to prevent the hopper from overflowing or go under an overhead obstruction.

Receiving the Aggregate

As soon as the aggregate begins to pour into the receiving hopper, the conveyor belts are turned on. The aggregate begins to flow into the discharge hopper and is distributed across the chipper head and discharge gates. When both the receiving and discharge hoppers are nearly full, the operator or his assistant signals the truck driver to stop raising or lower the truck box. This stops the flow of aggregate into the spreader.

Disengagement

A careful and experienced spreader operator will take extra precaution. He will disengage after the driver has lowered his box. The truck driver will lightly apply brakes to aid in disengagement and the spreader will move away from the trucks.

Spreading Aggregate

The operator must begin the dispensing of aggregate at the same speed that will be maintained throughout. Consequently, both operator and assistant must be ready to have the spreading fully underway as the front of the discharge hopper crosses the edge of the asphalt strip.

The operator must start the forward roll and maintain alignment of the spreader while reaching the correct forward speed. An instant before reaching the asphalt strip, he opens all the discharge gates. His assistant watches the flow of aggregate over the top of the discharge hopper. If any gates are not functioning correctly, he must immediately signal the operator to stop, unless the assistant can correct the problem immediately. If the problem can be corrected within the first few feet, the patching crew can fill in the bare spot easily.

The spreader operator backs the spreader a few feet from the spot where he ended. There he waits while the haul truck backs toward the spreader. The truck and spreader are joined together by the hitch again. The spreader operator has the truck driver raise the bed enough to keep the receiving hopper full.

As the spreader and truck move forward, the gates are opened just before reaching the bare asphalt. Excess aggregate at the point of double coverage will be swept off later or dislodged by traffic, so will do no harm. The operator continues to spread until the truck box is empty.

When the last of the aggregate has left the truck and entered the receiving hopper, the spreader assistant signals the truck driver to lower his truck bed. This will allow the truck to separate from the spreader without the tailgate or rear of the truck bed hitting the top of the receiving hopper.

Meet Line

There are two acceptable methods for applying chips to the meet line. The most common method is to leave a 4-6 inch strip of asphalt uncovered with chips. Then, on the second pass, the distributor will apply emulsion to the 4-6 inch strip again. This ensures a double or triple overlap of the asphalt. Chips are then applied to that area on the chip spreader's second pass.

The second method is to apply chips the same width as the applied asphalt. Prior to the second pass of the distributor, a power broom will broom back 4-6 inches of the first pass of the chip seal. This will remove any chips that failed to get adequate imbedment.

Direction of Travel

Generally, the chip spreader's first pass will be against traffic. This allows the chip spreader operator to match up the Meet line on subsequent chip spreader passes.

Prior to the start of a project, you should determine the direction you want to apply chips. You want to minimize haul trucks from traveling or turning around on the fresh chip seal.

Visual Checks

- You should watch as the chips hit the fresh asphalt. There should only be small bouncing action visible in front of the curtain of the aggregate.

- If a wave of asphalt forms in front of the curtain, either the asphalt or aggregate application rate is too heavy.

- Keep an eye on the scalping grate on top of the discharge hopper. If everything is going well, there should be a steady flow of aggregate passing through it. An accumulation of clay balls, grass, or rocks on top of the grate indicates that the loader operator is picking up contaminating materials. **Don't overfill the discharge hopper; keep chips below the scalping grate.**

- Also, look closely behind the spreader to check for contaminants and streaking of thin or thick rows of aggregate. Check for a ripple effect as well. If there is evidence of thick and thin alternating streaks running transversely (across the pavement), it indicates that the spreader speed is too high and should be slowed down.

HAUL TRUCKS

All trucks used on a seal coat project should be in reasonably good mechanical condition. They should be free from leaking fuel, crankcase or transmission oil, engine coolant, and hydraulic fluid. Leaking of these fluids onto a fresh seal coat can prevent proper bonding of the asphalt and aggregate. Mirrors need to be clean and adjusted. Brakes need to be adjusted to prevent wheel lockup. In addition, consider using the box tailgate apron or extension to aid in loading.

Single axle trucks normally carry from six to eight tons per load, depending upon the type of aggregate used on the job. These trucks usually have beds capable of holding five to six cubic yards of material.

Tandem axle trucks carry from 12 to 15 tons per load. The bed capacity is usually 8 or 10 cubic yards.

Tandem axle trucks mean fewer hookups and reduce the chance for spills. Every truck must be equipped with a hitch that matches the one on the spreader box. This is very important since the spreader box tows the truck as the load is being emptied. If the hitch does not hold the truck and spreader together securely, it could waste material and increase cleanup.

The truck driver then shifts the transmission into neutral to allow the spreader to tow the truck backwards as the aggregate is spread. Upon a signal from the spreader operator or his assistant, the truck driver releases the tailgate latch. He raises the truck bed as he is told and allows the aggregate to fill the receiving hopper. The truck driver must remain ready to lower the bed on signal to prevent the hopper from overflowing or hitting overhead obstructions, and also be watching his mirrors to stay lined up with the spreader. Drivers should avoid oversteering and wheels should be straight upon hookup or this could cause a bind between the spreader and truck.

When the last of the aggregate has left the truck box, the spreader assistant signals the truck driver to lower his truck bed. This will allow the truck to separate from the spreader without the tailgate or rear of the truck bed striking the top of the receiving hopper.

The spreader operator will normally continue to move forward while the truck box is being lowered and the truck is released. Before the spreader is completely empty, the operator

should stop the spreader. The operator should back up a few feet to allow the second truck to hookup.

Potential Problems

- Occasionally look at the tires on the haul trucks. If any of these show signs of asphalt sticking to them, especially asphalt and aggregate, immediately check further to determine the cause. There are many conditions that may cause truck tires to pick up asphalt, but usually it is one of two things. Either too much asphalt or too little aggregate has been applied at some point. It could have been a puddle of asphalt leaking or spilled on the pavement and not cleaned up before the aggregate was applied. Perhaps one of the discharge gates on the spreader clogged momentarily, preventing the aggregate from covering the asphalt.

  Regardless of the reason, the tires need to be cleaned and sand applied, or the situation will only get worse.

- Another problem to watch for is the improper operation of construction vehicles and equipment on the freshly placed aggregate. Inexperienced truck drivers can create problems, especially with tandem axle trucks.

  As the empty trucks pull away from the aggregate spreader, they occasionally accelerate too quickly or turn too sharply. Accelerating too hard will sometimes cause a tire to spin because of the wet asphalt and unrolled aggregate. Turning too sharply, as in turning around with tandem axle trucks, can cause the aggregate to turn over, exposing some of the asphalt. Either of these situations can happen easily. It can cause the aggregate and asphalt to begin sticking to tires if the scuffing is severe enough.

- Watch for drivers applying their brakes too sharply. This may cause the wheels to lock and shove aggregate aside, exposing bare asphalt. The effect is the same -- or worse -- than those described above.

  If any of these situations occur, have the patching crew repair the spot before the rollers get to that spot.

- Air brake cans center plugs (spring brake release bolt cover plug) and hydraulic quick connects should have covers. These could create a loss of hydraulic fluid and/or cause other mechanical problems.

- Haul trucks should always stagger their wheel paths.

ROLLERS

Once the asphalt has been sprayed and covered with a layer of aggregate, the chip seal must be rolled. This is done to orient the aggregate in its flattest dimension and seat it firmly into the asphalt binder. Rolling equipment is critical to the final outcome of the project. Some rolling is accomplished by the trucks backing up. **Truck drivers must remember it is critical for them to stagger their wheelpath.**

Numerous types of rollers can be used on a chip seal. They are:

- pneumatic-tired rollers
- steel-wheeled tandem rollers
- single drum steel-wheeled rollers

The rationale behind not allowing steel-wheeled rollers on the chip seal is the belief that the flat, steel drum will tend to crush the aggregate on the high spots. However, as a last resort, we recommend using them in lieu of not rolling

Pneumatic Rollers

For the purpose of this manual, we will concentrate on pneumatic rollers. Pneumatic rollers operate on rubber air-inflated (pneumatic) tires. The tires themselves provide the forces needed to seat the aggregate firmly in the asphalt binder in a uniform arrangement.

Many of MDT's pneumatic rollers are capable of ballast loading to uniformly vary the total roller weight. Wet sand or aggregate may be used for ballast. However, pavement contact pressure being exerted by each tire on the roller is a more accurate measurement of the forces being exerted on the pavement.

Contact pressure is a function of:

- total vehicle weight;
- number of tires, tire size and rating;
- tire inflation pressure.

All tires must have a smooth surface.

Tire Inflation

We recommend that all tires be identical and inflated so that there is no more than five pounds PSI variation from one tire to the next. We cannot overemphasize the importance of maintaining correct tire pressure. If one tire is soft, it will not seat the aggregate as firmly as the other tires, and this could result in aggregate, in that path, stripping away under traffic.

Wheel Wobble

The wheels must not wobble when the roller is in operation. This will cause the aggregate to be displaced and could ruin the whole chip seal job. If any wheel on any of the rollers can be seen wobbling, it is too much, and the roller should not be allowed on the project until it is repaired.

Smooth Operation

All rollers must be capable of smooth operation, especially when turning, stopping, or starting. If the brakes or drive train are faulty and cause jerking or excessive vibration when the roller is stopped or started, it should not be allowed to continue operation. If one of the wheels is out of alignment, it may cause "scuffing" when the roller is turned. None of these conditions should be permitted on the job since premature failure of the chip seal will probably occur.

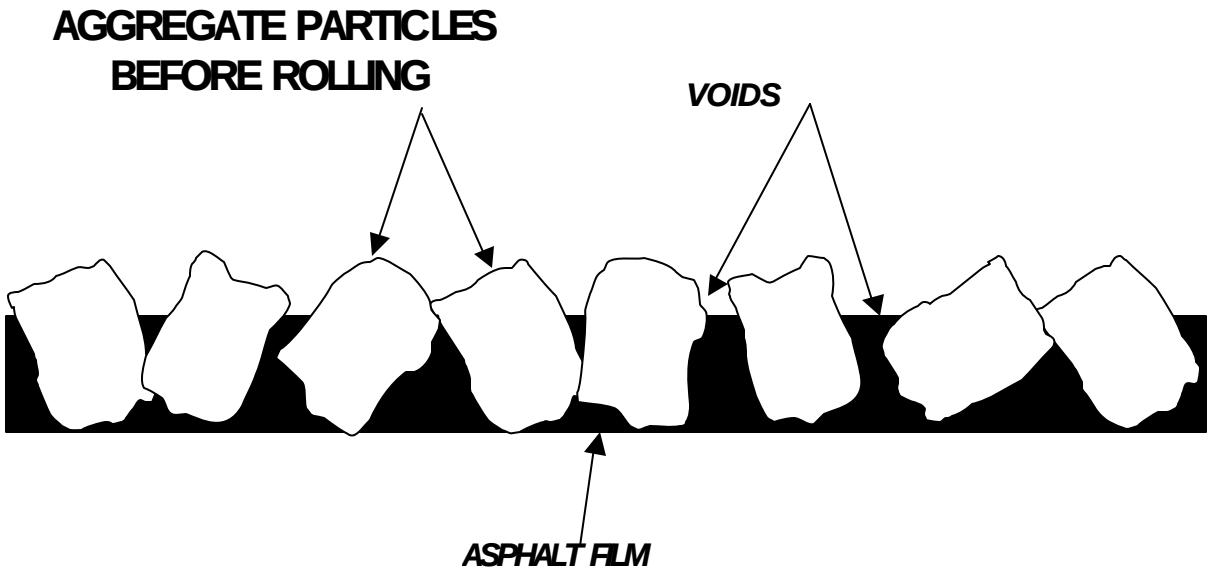
Roller Operation

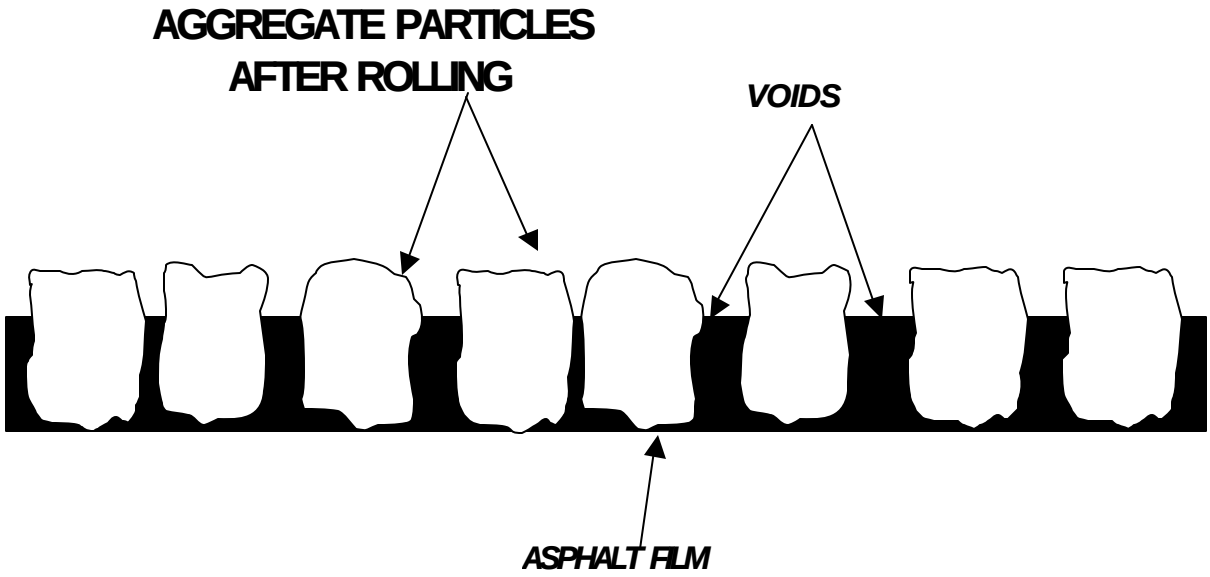
Normally, rolling does not begin until the majority of other equipment has moved some distance down the roadway. There are three main reasons. First, there will be aggregate trucks moving onto and off the freshly placed aggregate mat. Secondly, it is usually desirable to allow any patchwork plenty of time to be done if a patching crew is used. Finally, it is a good idea to allow the asphalt binder to firm up slightly. Of course, during cool weather, this happens quickly. The cooler the weather, the more quickly the rolling must be completed.

The methods and rolling pattern used for seal coats will depend largely on the number and type of rollers used.

Probably the most efficient rolling system will involve the use of two pneumatic rollers. With this equipment, it is possible to provide adequate coverage with no more than three passes: one forward, one in reverse, and the final pass forward extending into the first pass of the next section. This would normally be the minimum that is required; it is usually better to continue having the rollers operate rather than sitting idle. Normally, the more rolling the

better, unless it is degrading or crushing the aggregate, which could happen with a steel-wheeled roller. **Roller speed should not exceed 3-6 miles per hour, or a fast walking speed.**


AGGREGATE PARTICLES
BEFORE ROLLING
VOIDS
ASPHALT FILM


AGGREGATE PARTICLES
AFTER ROLLING
VOIDS
ASPHALT FILM

BROOMS

Before any asphalt is shot on a chip seal project, the roadway must be thoroughly cleaned. We recommend that you do this two to three days prior to the project start. Then, a quick check of the project on the start date for any mud tracked onto the roadway from approaches. Power brooms are excellent for this purpose.

The bristles may be nylon or fiber. Some use a combination of nylon and steel bristles, which give excellent results. Our primary concern with the rotary broom is that the bristles are in good condition. They should not be excessively worn or worn unevenly. Uneven wear may prevent thorough cleaning of part of the pavement surface. If the bristles are excessively worn, they should be replaced.

Brooming off the Excess Aggregate

After the aggregate is spread and rolled and the roadway is reopened to traffic, there will be some loose aggregate left on the surface. Not every particle of aggregate will be held in place by the asphalt binder. This excess aggregate must be removed, otherwise, it will be whipped up by automobile tires; windshield and paint damage will result. **Brooming or sweeping of the project can begin 24 hours after the chips have been applied.**

If you are using a CRS-2P and are in an urban environment or on a high-speed volume roadway, you can do a light brooming after 4-5 hours. Then follow up with a heavier brooming the next day.

As we mentioned earlier, the cover aggregate is rolled to orient the particles with their widest side in contact with the asphalt binder. Rolling will also move the particles sideways in one direction or another as particles on top are forced down into the asphalt binder. This results in most of the aggregate particles having at least some contact with the asphalt. The particles on top will have either very little or no contact with the aggregate binder.

Prior to brooming, we highly recommend wetting the roadway surface with a water flush truck to reduce dust. **There are no specific procedures that must be followed, but there is a logical pattern that is recommended.** If the road is two-lane, the sweeper should begin at the centerline and sweep the aggregate toward the right side on the first pass. At the end of the seal coat, the sweeper would turn around and sweep the inside of the other lane in the opposite direction. The second pass should be on the outside edge and possibly the shoulder

if the road is narrow enough to be completely swept with two passes in each direction. Two brooms sweeping together is recommended.

Regardless of how many passes are required, the objective is to broom the excess aggregate off the roadway surface and shoulder onto the side of the road. You need to inspect the brooming operation to ensure that all the excess aggregate is removed and to be certain that the sweeper does not dislodge the aggregate that is imbedded in the asphalt binder. We also have a responsibility to ensure that the sweeping is done safely and with a minimum of interruption or delay of traffic.

Sweeping should continue until you are satisfied that as much excess aggregate as possible has been removed.

CAUTION: Stopping the broom with the brushes down and engaged can damage a fresh chip job.

FLUSH TRUCKS

We recommend that flush truck be utilized on each chip seal project. A flush truck serves two functions on a project. First, is to wet down the aggregate stockpile. If you have a long project and the temperature is hot, the stockpile may need to be wet down more than once.

Secondly, one should be used to wet down the chip seal during the brooming operation. This will greatly enhance dust control during brooming.

CLEANUP CREW

The use of a cleanup crew can help ensure a successful project. A cleanup crew uses a one-ton loaded with chips and with a plow attached. The plow has hard rubber wheels in place of the plow shoe on each end.

As streaks occur, leaving fresh asphalt unchipped, the crew spreads chips over the exposed asphalt. Secondly, as aggregate spills occur, the plow is used to push the aggregate spill off the roadway. This helps eliminate a potential roadway hazard and keeps the project moving.

ON-SITE MECHANIC

We recommend that a mechanic be on-site during the chip seal operation. The mechanic should have some common spare parts (oil, hydraulic fluid, compressor, etc.), on hand. For major parts (chip spreader belt, etc.), have the Shop Superintendent or Maintenance Superintendent locate them prior to the project.

If a mechanic is on-site, minor repairs can be made with little down time to the equipment or the entire operation. If a mechanic has to travel to the project to make repairs, the entire operation may be slowed down or stopped, depending on downed equipment.

CHAPTER 4

OPERATIONAL CONSIDERATIONS

CHAPTER 4 - OPERATIONAL CONSIDERATIONS

WEATHER CONSIDERATIONS

Weather plays an extremely important role in a chip seal operation. A sudden change of weather may adversely effect the project.

The ideal conditions for applying a chip seal are hot temperatures with relatively low humidity, and little or no wind. This is a difficult order to fill in many parts of the state. There are, however, periods when weather patterns are more likely to follow these requirements than at other times. Too early in the spring or too late in the fall brings temperature and wind problems. **This is why MDT specifications recommend chip seals only be done between May 1 and August 31. Any exceptions will be handled on a case-by-case basis by the Division Administrator.** Always check the extended forecast.

Our Standard Specifications require that chip seals be applied when the roadway surface is 65°F and rising. In most cases, between May 1 and August 31, temperature is not a major problem, except in shaded areas. You must, however, check the surface temperature every morning before any asphalt is shot. This is done using an infrared surface thermometer.

Humidity

It is best if the humidity is 50 percent or lower when the asphalt is shot, especially if you are shooting emulsions. With any asphalt, the lower the humidity, the better. High humidity will cause an invisible film of moisture to collect on the roadway surface, which detract from the asphalt sticking properly to the surface. With emulsified asphalts, the emulsion will be slower breaking in high humidity. You will often see small bubbles forming and breaking as the air and moisture works its way to the asphalt surface.

Wind

Wind may work partially in your favor and against you at the same time. A gentle wind, if it is constant in speed and direction, can help to break the emulsion sooner. It will generally allow you to apply the cover aggregate closer behind the asphalt distributor. This can reduce some of the potential for problems that usually comes when the distributor gets too far ahead.

The farther ahead the distributor gets, the higher the chance of traffic crossing the fresh asphalt, which always seems to happen.

On the other hand, if the wind is too strong, it causes problems. It will distort the fan pattern as the asphalt is forced, under pressure, out of the spray nozzles. This may cause streaking and uneven distribution.

Wind always tends to help "decorate" passing automobiles with asphalt specks. You have to be very carefully of wind direction, especially when spraying emulsion with latex. It is a very sticky substance, and as it is sprayed, small "cobwebs" of the mixture are blown around. They are almost invisible until they land on a light-colored automobile, at which time they become very obvious.

Wind may force a change in plans as to which lane is shot first, and the direction of work, in order to minimize the effects of blowing asphalt.

Rain

Asphalt should never be shot during rain. If rain is in the vicinity and predicted for the area, you probably should suspend operations until it clears. It is better to be safe than to have 12,000 square yards washed off the road into the ditch.

Sudden, unexpected showers are common. Sometimes they appear with no hint of rain and pass very quickly. In this case, shut off the asphalt distributor immediately and wait until the shower is gone and the pavement dries. But, it is usually best to continue operation of the aggregate spreader until the asphalt shot is completely covered.

After a rain, always suspend operations until the pavement has ample time to dry. Recheck pavement temperatures and be aware of the increased humidity.

CALIBRATION PROCEDURES

DISTRIBUTOR CALIBRATION

The following is a step-by-step procedure to calibrate a distributor and calculate the application rate.

1. Determine the number of gallons in the distributor. This can be done by several methods. The first and most accurate is to weigh the distributor before loading and after loading. Subtract the weights and divide by the pounds per gallon the emulsion weighs. This equals the total gallons.

   The second method is to find a level spot (the distributor tank must be level). Use a dip stick to dip the tank. Measure the number of inches covered with asphalt. After you know the size of the tank, you can calculate the number of gallons in the tank.

   The third method is, you can use the meter on the distributor tank. This is a good check but is **not recommended** for calibrating purposes.

   Method 1 and 2 are recommended for MDT equipment prior to the start of the project.

2. Apply asphalt to a known distance (minimum 200 feet) and established width.

3. Determine the total square yards covered with emulsion. This can be done by doing the following math:

$$\frac{\text{Length Traveled (feet)} \times \text{Width Covered (feet)}}{9} = \text{Square Yards}$$

4. Determine the number of gallons remaining on the distributor. Again, use Method 1 or Method 2 explained in Step 1.

5. Subtract the total gallons on the distributor originally from the total gallons left on after applying asphalt. This will give the gallons used.

   Original Gallons - Remaining Gallons = Gallons Used

6. Divide the total gallons used by the total square yards covered to determine the application rate in gallons per square yard.

   Total Gallons = Gallons/Square Yards
   Total Sq. Yds.

7. **To calculate your application on the project,** follow the same steps except use Method 3 outlined in Step 1 to determine the number of gallons on the distributor. (This includes contracted distributors.)

CHIP SPREADER CALIBRATION

The following is a step-by-step procedure to calibrate your chip spreader and calculate the application rate.

1. Construct a one square yard shallow box or tarp, with shallow and narrow sides.

2. Place the box/tarp in line with of the chip spreader pass, a minimum of 50 feet in front of the chip spreader. Remember to calibrate across the entire head of the chip spreader. This will require 3 or 4 passes.

3. Get the chip spreader up to speed and apply chips over the top of the box/tarp.

4. Remove the box/tarp with the chips from the road.

5. Find an accurate materials scale. If in the field, the scale must be leveled and checked.

6. Place the chips from the box/tarp in a small bucket and weigh the bucket with the chips.

7. Empty the chips out and weigh the empty bucket.

8. Subtract the weight of the empty bucket from the weight of the bucket with the chips.

9. Since you had a one-square yard box/tarp, the weight from Step 8 is your pounds per square yard of chips.

10. Repeat the process at two to three gears and two to three RPM or speeds. You can then develop a chart.

11. Repeat the process for both 4A and 5A material .

    NOTE: The aggregate weight may vary a couple of pounds if the chips are wet.

URBAN CONSIDERATIONS

Traffic Control

A much more extensive traffic control plan is required for chip jobs in urban areas. Side streets entering into the work area need detours and additional personnel for traffic control. Increased traffic volumes require larger storage space for stopped vehicles waiting to be piloted through the work zone and additional pilot vehicles should be considered. Traffic signals may need to be disabled and flaggers used when the project interferes with normal traffic through intersections.

Overhead Obstructions

Extreme care should be used by the crew when loading the chip spreader with trucks. Overhead power lines, intersection lights and trees can be hit by raised boxes on dump trucks. The person assigned to connect and disconnect trucks to the chip spreader should be aware of any obstructions and tell the drivers, through hand motions, when to safely raise and lower their boxes. Good Communications on the spreader is very important here.

Cure Time

Traffic turning on the new chip job can dislodge aggregate and generally reduce the overall quality of the job. Be sure to allow enough time with your traffic control for the surface to cure adequately.

Distributor

Go through the project area with the distributor operator and look for special problem areas such as turn bays or utility access covers (manholes). Decide how you want them shot and if you need someone on the ground in those locations to give hand signals to the distributor operator. Parking for the tanker feeding the distributor will require additional planning.

Sweeping

Sweeping the project may require more traffic control than normal. Consider the same traffic control plan for sweeping as you had for applying materials. Special attention should be used for dust control during the sweeping process.

Materials

Your choice of asphalt/emulsion can be critical to the success of your urban project. We highly recommend you use polymer or latex modified emulsions. Straight high float emulsions should not be used for urban projects.

You may want to consider using a straight asphalt cement (PG 64-22, etc.) for urban projects. Other states use them for urban environments with success. We strongly recommend that if you are going to use an emulsion that you use a CRS-2P. The main advantage both is the ability to broom the project 3-4 hours after applying the chips. The disadvantage is the application temperature for the straight asphalt (250°-400°F) is extremely hot and chips must be applied immediately behind the distributor without delays.

Due to dust considerations, we recommend that you use a Grade 4A for urban projects.

FOG SEALING CONSIDERATIONS

Introduction

Fog seals are a light application of diluted asphalt emulsion without an aggregate cover. Fog seals have a variety of uses such as seals small cracks, rejuvenated raveled or slightly oxidized pavements, and for sealing chip seals and open grade friction courses. For the purpose of this section, we will address it use on sealing chip seals.

Materials

The material used for fog sealing is either an anionic or cationic slow-setting emulsion, such as an SS-1 diluted with water. Water is added to reduce the viscosity of the emulsion. This allows for better control of the application and penetration of the emulsion into the voids. Generally, the emulsion is diluted one part water to one part emulsion (1 to 1). Other dilution rates such as 2 or 3 to 1 can be done as well.

Application Rate

Before you decide to fog seal your chip seal project, check the embedment of your chips. Your percent embedment should dictate your application rates.

It is highly recommended that you use two or three lighter applications rather than one heavy application rate. The reason is this allows you the opportunity to make adjustments. One heavy application could result in a flushed surface and adversely affecting skid resistance.

A good application rate is usually .04-.10 gallon/sq. yd.

If your chip seal project has greater than 80 percent embedment, it is recommended that you don't fog seal.

Weather Condition

Fog seals should never be applied when the pavement temperature is below 35°F and/or there is a threat of rain. Both will reduce the curing of the emulsion.

Construction Considerations

Ensure that the distributor is calibrated before using. It is critical that the proper application rate is used. Over application must be avoided to prevent asphalt pickup by vehicles and a slippery surface. If excess emulsion is applied, a light dusting with sand may be a temporary remedy for the problem.

Benefits

- Reduces the amount of loose “fly” rock.
- Reduces the number of broken windshields.
- Increases aggregate embedment.
- Improves pavement-marking contrast.

CONTRACTING DISTRIBUTORS

Reasons

We recommend hiring a distributor to shoot your asphalt. There are a few reasons to hire a distributor: reduce manpower requirements, increase efficiency (due to computerization and larger distributors), and overall cost effectiveness.

How

If you are interested in hiring a distributor, you **must** go through the refinery supplying the asphalt. We recommend that when you supply the refinery with your list of projects and tentative start dates, include your distributor needs at that time. If you need distributors, be sure to check with the refinery at least two weeks prior to the project.

If your project is large enough, we recommend you consider using two distributors. This makes the project go faster and eliminates the down time when the distributor is refilling. The cost will be about the same, since it will be based on the tons of asphalt applied.

CAUTION: If you are going to use two distributors, make sure you can keep both busy for a full day, not just a half-day.

LIST OF GOOD PRACTICES

1. Is a chip seal the proper strategy for the project?
2. Good SMP planning.
3. Delegation of key project responsibilities.
4. Communicate with the public about project.
5. Pre-project meeting.
6. Proper selection of materials based on chip design.
7. Stockpile watered down.
8. Attention to weather factors (temperature, humidity, etc.)
9. Good traffic control, flagging and piloting operations.
10. Distributor and chip spreader calibrated
11. Good asphalt uniformity and application rate.
12. Good chip uniformity and application rate (salt and pepper appearance).
13. Proper haul truck techniques (staggering wheelpath, no turning on fresh chips, etc.)
14. Proper roller techniques (speed, timing, etc.).
15. Good sweeping operation (traffic control, flush truck, etc.).
16. Re-stripe the surface after sweeping.

CHIP SEAL CHECKLIST

The following is a checklist of various chip seal considerations. Those options bolded indicate options to avoid. Those bolded options could greatly reduce the chip seal life or create a premature failure. If you have several bolded options, you should evaluate what areas to change.

Is this a good chip seal candidate?

1. Alligator cracking severity.
   a. severe b. moderate c. minor d. none

2. How much alligator cracking is there?
   a. 0% b. 0-5% c. 5-15% **d. >15%**

3. Rutting severity.
   a. 0-½" b. ½-¾" **c. >¾"**

4. How much rutting is there?
   a. 0% b. 0-10% **c. 10-30% d. >30%**

5. Type of raveling.
   a. none b. fine **c. coarse**

6. How much raveling?
   a. 0% b. 0-10% c. 10-30% **d. >30%**

7. Flushing or bleeding severity.
   a. severe b. moderate c. minor d. none

8. How much flushing or bleeding?
   a. 0% b. 0-10% **c. 10-30% d. >30%**

9. Pavement breakup severity.
   a. severe b. moderate c. minor d. none

10. How much breakup?
    a. 0% b. 0-10% **c. 10-20% d. >20%**

11. Transverse/Longitudinal cracks.
    a. <¼" **b. >¼"** c. filled
    (rubberized filler?_____) (asphalt filler?_____)

Aggregate and Chip Design Considerations

1. Has a chip seal design been done?
    a. Yes **b. No**

2. What is the ADT?
    a. high b. moderate c. low

3. Cleanness of aggregate: (dust on aggregate)
    a. clean b. slightly dirty c. somewhat dirty **d. dirty**

4. Percent of fines passing 200.
    a. 0-2% b. 2-5% c. 5-10% **d. >10%**

5. Aggregate moisture.
    a. dry b. damp c. somewhat wet **d. wet**

    Total gallons of asphalt required for project. _____
    Total tons of chip required for project. _____
    Asphalt application rate. _____
    Aggregate application rate. _____

Environmental Considerations

1. Humidity.
    a. raining b. somewhat humid c. somewhat dry d. dry

2. Date of work.
    a. before May b. May 1-August 20 **c. after August 31**

3. Wind.
   a. windy b. somewhat windy c. somewhat calm d. calm

4. Air temperature.
   a. below 65 b. 65-75 c. 75-95 d. above 95

5. Surface moisture at the time of treatment.
   a. dry b. mostly dry c. somewhat wet **d. wet**

6. Pavement temperature.
   a. below 65 b. 65-75 c. 75-95 d. >95

Materials/Equipment Considerations

1. Type of asphalt.
   a. CRS b. High Float c. cut back
   (source of asphalt? _____)

2. Distributor cleaned before use?
   a. yes **b. no**

3. Distributor has a full circulatory system?
   a. yes **b. no**

4. Distributor calibrated?
   a. yes **b. no**

5. Aggregate spreader calibrated?
   a. yes **b. no**

6. Asphalt temp (125°-180°F)?
   a. above b. acceptable **c. below**

7. Truck box cleaned before use?
   a. yes **b. no**

8. Pneumatic tire roller? _____
   a. weighted **b. unweighted** c. partially weighted

9. Roadway cleanness at the time of treatment.
   a. clean b. mostly clean c. somewhat dirty **d. dirty**

Technique Considerations

1. Chip design followed?
   a. yes b. closely c. somewhat **d. no**

2. Atomization noticed?
   a. yes b. usually c. sometimes d. no

3. Asphalt application uniform?
   a. yes b. usually c. sometimes **d. no**

4. Spray bar set to proper height?
   a. yes b. usually **c. sometimes d. no**

5. Trucks match up with spreader?
   a. yes **b. no**

6. Aggregate spread uniformly?
   a. yes b. mostly **c. somewhat d. no**

7. Aggregate streaking notice?
   a. yes b. mostly c. somewhat d. no

8. Foreign materials in the chips causing plug-ups and streaking?
   a. yes b. no c. sometimes

9. Is there any evidence of bleeding during the project?
   a. yes b. no c. sometimes

10. Does sealed surface have salt and pepper appearance?
    a. yes **b. no**

11. Time to begin rolling after spreading aggregate.
    a. <10 seconds b. 10-60 seconds c. 1-5 minutes **d. >5 minutes**

12. Number of rolling passes.
    a. 0 b. 2 c. 3 d. >3

13. Time to complete rolling.
    a. <5 minutes b. 5-15 minutes c. 15-30 minutes **d. >30 minutes**

14. Roller speed < than 6 mph?
    a. yes b. usually **c. sometimes d. no**

15. Percent of aggregate imbedment.
    a. >70% b. 50-70% c. 30-50% **d. <30%**

16. Time before traffic applied after chips have been rolled.
    a. <5 minutes b. 5 minutes-1 hour c. 1-3 hours d. >3 hours

17. Traffic kept off until rolling has been completed?
    a. yes b. mostly c. somewhat **d. no**

18. Time traffic controlled using a pilot car.
    a. 0 hours b. 1-8 hours c. 8-12 hours d. 12-24 hours

19. Type of traffic control.
    a. pilot b. flagman c. signs d. all

20. Maximum traffic speed.
    a. <20 mph b. 20-30 mph **c. 30-40 mph d. >40 mph**

21. Time before brooming.
    a. 1-8 hours b. 8-12 hours c. 12-24 hours d. >24 hours

22. Aggregate loss from brooming.
    a. none b. little c. moderate **d. considerable**

Emulsions

1. Time before aggregate applied after asphalt is applied.
   a. <10 seconds b. 10-60 seconds c. 1-4 minutes **d. >4 minutes**

CHAPTER 5

TRAFFIC CONSIDERATIONS

CHAPTER 5 - TRAFFIC CONSIDERATIONS

We recommend that one person be in charge of a crew whose sole responsibility is traffic control. Their duties include erecting temporary post-mounted signs, placing and moving temporary signs, flagging and piloting operations.

If temporary post-mounted signs are used, they must be covered until they are needed. Any permanent signs that are in conflict with the project must be covered until the project is complete.

Sign Setup

The first thing that occurs prior to start-up should be the correct positioning of signs. The timing is critical because motorists must come under control of the warning signs before any equipment is moved onto the highway. Be sure there is adequate storage of stopped vehicles during normal piloting operations.

Check to ensure that all signs specified in the Traffic Control Plan and/or Zone Safety Guideline handbook are:

- in good condition;
- in the proper sequence;
- the correct distance apart;
- clearly visible to motorists;
- positioned correctly so the devices themselves do not pose a hazard to traffic; and
- FHWA has indicated that you may place a cone by the sign to help draw attention to the sign.

Flagger

As soon as the flagger sign is placed in position, a flagger should also be in position. You should ensure the flagger is using the correct signals. If the flagger is required to verbally explain the situation to vehicle operators, listen to what he or she tells a few of the drivers to make certain it is clear and accurate.

If there are flaggers at both ends of the project, which there usually will be on a two-lane road, make certain they have whatever communications are necessary. Also, ensure that the communications are properly used.

Always remember that the flaggers are vital to the safety of motorists and workers in the construction area. If they are not performing any element of their duties properly, they must be corrected promptly. Refer to the MDT flagger manual for proper flagging requirements.

Moving Signs

Later in the day, after some distance has been covered, the flagger and signs may need to be moved closer to the operations and the first part sealed opened to traffic with reduced speed signs in place. Check the flagging and signs again to ensure proper placement and procedures after they are repositioned.

Intersection

If the chip seal operation crosses any intersections, extreme care must be taken. Be sure the traffic control plan is followed; you may need additional signs and flaggers at the intersection. Care must be taken to prevent vehicles from crossing the wet asphalt.

Pilot Car

We recommend you pilot the fresh chip seal until dark. You also may want to consider utilizing a piloting car during brooming operations. When piloting on the fresh chip seal, you should keep speeds under 25 mph and stagger wheel paths. If you don't adhere to the speed guidelines and staggering the trafficked wheel paths, the chips will be dislodged and/or rolled over, creating a bleeding situation.

To determine how many pilot cars you need, consider the following factors:

- ADT
- roadway width
- length being piloted
- man power availability
- number of major intersections
- adequate communication

Appropriate Work Zone Signs

Two-Lane Roadway

$ Road Work Ahead
$ Fines Double in Work Zones
$ Reduce Speed Ahead
$ Flagger Ahead
*Need two sets minimum, one on each end of the project.

Interstate

$ Road Work Ahead
$ Fines Double in Work Zones
$ Reduce Speed Ahead
$ Right/Left Lane Closed ½ Mile
$ Speed Limit 55
$ Arrow Board
$ Resume Speed
$ Requires Cones
*Need two sets, one on each side of the roadway. An additional set is recommended.

Other Required Signs

- Loose Gravel
- 35 mph Speed Limit
- Reduce Speed Ahead
- Do Not Pass

Optional Temporary Post-Mounted Signs

- Loose Gravel
- Do Not Pass

If you have any questions about the correct signs or spacing, consult:

- Guidelines for Work Zone Safety
- MUTCD
- Traffic Engineer

POINTS OF 61-8-314, MCA:

① CONSTRUCTION ZONE MAY INCLUDE A WORK ZONE.

② SIGNS IDENTIFY THE BOUNDARIES OF EACH.

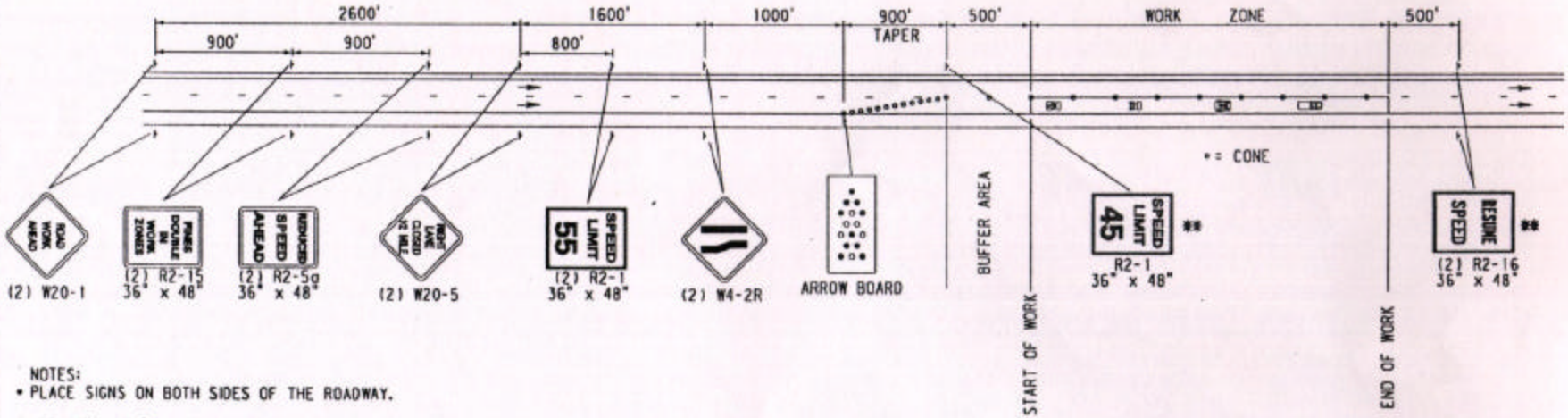
③ SEPARATE SPEEDS CAN BE SET FOR EACH

④ DOUBLE PENALTY SIGN MUST BE AT CONSTRUCTION ZONE BOUNDARY.

⑤ DOUBLE PENALTY APPLIES TO WORK ZONE.

⑥ WORK ZONE CANNOT EXCEED ACTUAL ACTIVITY AREA BY MORE THAN 500'.

** WHEN THE WORK ZONE CHANGES WITHIN THE CONSTRUCTION ZONE THESE SIGNS SHOULD BE MOVED TO REFLECT THE ACTUAL WORK ZONE.



NOTES:

- PLACE SIGNS ON BOTH SIDES OF THE ROADWAY.
- USE 48" x 48" WARNING SIGNS.
- USE THIRTEEN APPROVED CHANNELING DEVICES FOR A 12' LANE CLOSURE TAPER. (75 M.P.H. SPACED AT 75'). ASSURE THAT THE TAPER IS A MINIMUM LENGTH OF 900'.
- SPACE CHANNELIZING DEVICES AT INTERVALS OF TWICE THE SPEED LIMIT (IN FEET) THROUGH BUFFER AND WORK AREA.
- PLACE THE ARROW BOARD (IF USED) ON THE SHOULDER AT THE START OF THE TRAVEL LANE CLOSURE TAPER.
- KEEP THE BUFFER AREA CLEAR OF EQUIPMENT AND PERSONNEL.
- FOR MORE INFORMATION OR CLARIFICATION CONTACT THE DISTRICT TRAFFIC ENGINEER. FOR EXAMPLE, IF WORK AREA IS CLOSE TO A HORIZONTAL CURVE, A VERTICAL CURVE, A BRIDGE, INTERCHANGE, POOR SIGHT DISTANCE OR OTHER SPECIAL CONDITION.
- COVER ANY CONFLICTING SIGNS IN THE WORK AREA.
- SHORT-TERM WORK ZONE SIGNING IS NOT REQUIRED TO BE POST MOUNTED.

DETAILED DRAWING

REFERENCE STANDARD SPEC. SECTION — DWG. NO.

MAINTENANCE GUIDELINE FOR SHORT-TERM LANE CLOSURE ON INTERSTATE

EFFECTIVE:

MONTANA DEPARTMENT OF TRANSPORTATION — MONTANA CADD

POINTS OF 61-8-314, MCA:

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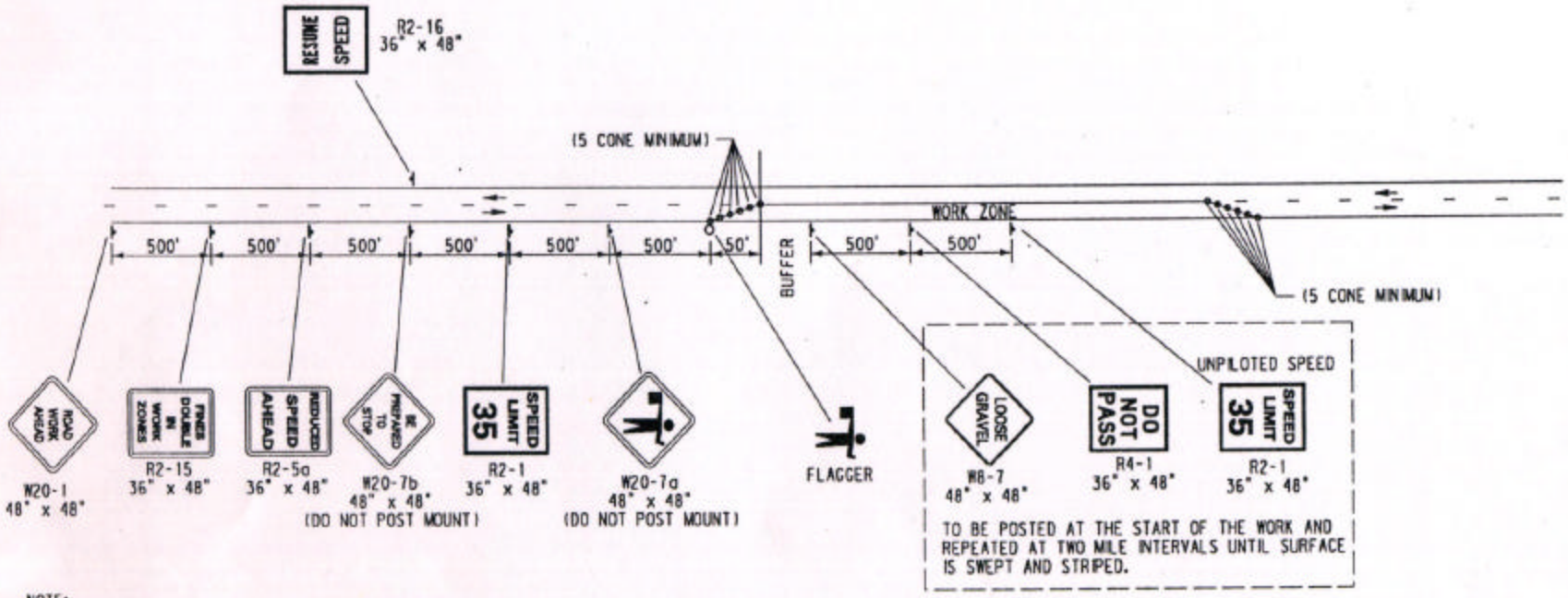

NOTE:

- ON ROADWAYS WITH HIGH TRAFFIC VOLUMES OR VISIBILITY RESTRICTIONS A 500' SPACING FOR ALL SIGNS IS RECOMMENDED.
- IF A NEED ARISES TO INCREASE VEHICLE STORAGE, ADD AN ADDITIONAL W20-7a "FLAGGER AHEAD" SIGN BETWEEN THE R2-1 AND THE ORIGINAL W20-7a AND CONSIDER AN ADDITIONAL FLAGGER AND STATION.
- A MIRROR IMAGE OF THIS SIGN SEQUENCE IS REQUIRED FOR THE TRAFFIC FROM THE OPPOSITE DIRECTION.
- RESUME SPEED SIGN SHOULD BE OPPOSITE THE BE PREPARED TO STOP SIGN FOR TRAFFIC LEAVING THE WORK ZONE.
- FOR MORE INFORMATION OR CLARIFICATION CONTACT THE DISTRICT TRAFFIC ENGINEER. FOR EXAMPLE, IF WORK ZONE IS CLOSE TO A HORIZONTAL CURVE, A VERTICAL CURVE, A BRIDGE, INTERCHANGE, POOR SIGHT DISTANCE OR OTHER SPECIAL CONDITION.
- COVER ANY CONFLICTING SIGNS IN THE WORK ZONE.
- SHORT-TERM WORK ZONE SIGNING IS NOT REQUIRED TO BE POST MOUNTED.

DETAILED DRAWING

REFERENCE STANDARD SPEC. SECTION — DWG. NO.

MAINTENANCE GUIDELINE FOR SHORT-TERM TWO-LANE CHIP SEAL & OVERLAY (PILOTED TRAFFIC)

EFFECTIVE:

MONTANA DEPARTMENT OF TRANSPORTATION — MONTANA CADD

APPENDIX A

GLOSSARY OF TERMS

APPENDIX A - GLOSSARY OF TERMS

Aggregate — A hard, granular material of mineral composition such as sand, gravel, slag, or crushed stone, used for covering the asphalt seal in seal coats.

Coarse Aggregate: Aggregate retained on the 6.35 mm (No. 4) sieve.

Fine Aggregate: That passing the 6.35 mm (No. 4) sieve.

Anionic — See "Emulsified Asphalt."

Asphalt — A dark brown or black bituminous material, either natural or refined from petroleum, used to seal roadway surfaces and to bond the aggregate particles securely to the surface. Asphalt is a thermoplastic material, since its viscosity changes with temperature.

Asphalt Cement — Asphalt which has been specifically prepared or refined to standards of quality and consistency. It is prepared for direct use as a sealer and binder used in seal coats and surface treatments. It is commonly abbreviated and referred to as "AC."

Bitumeter Wheel — The small wheel on an asphalt distributor which measures distance traveled in linear feet. It is often erroneously called a tachometer.

Bleeding — The upward movement of asphalt in an asphalt pavement, resulting in a smooth film of asphalt forming on the pavement surface. It appears in patches of dark, smooth surface, usually in the wheel paths and becoming more acute during hot weather. Bleeding can be compounded by adding more asphalt in a seal coat unless the applied quantity is decreased over the bleeding areas.

Breaking (of an emulsion) The point when water and emulsifying agent begins to evaporate, result of exposure to the atmosphere, from an emulsified asphalt. See also "Emulsified Asphalt" and "Emulsions."

Burner A heating unit on an asphalt distributor or heater tank, used to keep asphalt at spraying temperature. The burners usually burn either diesel oil or propane gas. Asphalt distributors usually have two burners which direct a flame into flues passing through the tank to distribute the heat evenly.

Calibrate Checking an asphalt distributor to ensure the measuring devices are accurate.

Cationic See "Emulsified Asphalt."

Chip Seal Another term for seal coat. The term "chip seal" is derived from "rock chips" which are actually crushed rock or gravel particles.

Chip Spreader This is a trade name for an aggregate spreader or "spreader box," as it commonly called.

Cracks Breaks in the surface of an asphalt pavement.

Alligator Cracks: Interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken wire, caused by excessive deflection of the surface over unstable subgrade or lower courses of the pavement.

Cutback Asphalt Asphalt cement which has been combined with petroleum solvents (also called "diluents") to make the asphalt less viscous. Upon exposure to the atmosphere, the solvent evaporates, leaving only the asphalt cement to harden. Cutback asphalt has been used less in recent years for seal coat and surface treatment work because of the need for air quality.

Durability The ability of a surface treatment or seal coat to resist the effects of weather and traffic and retain its desirable properties. To be considered durable, the surface should retain its skid resistance.

Emulsified Asphalt Asphalt cement mixed with water to liquefy it. Since water and asphalt do not normally mix, an emulsifying agent (chemical) is also added in small quantities. When the water and emulsifying agent evaporates, the basic asphalt cement remains to harden and hold the aggregate particles in place. Emulsions are either anionic (electronegatively charged) or cationic (electropositively charged), depending upon the type of emulsifying agent used. The mixing process is the same for both types. Extreme care must be taken to ensure that cationic and anionic emulsions are never mixed.

Emulsions A simplified term referring to emulsified asphalt.

Fines A collective term referring to fine aggregate (aggregate with small diameter particles) and mineral filler. The amount of fines in an aggregate is important because the fine particles may be totally imbedded in the asphalt binder.

Flash Point The temperature at which asphalt will burn when exposed to an open flame. This does not meant that if it is heated to this temperature in a closed container that it will ignite. There must be a flame present, and, of course, air. But the flash point is the danger zone, and extreme care must be taken because it will burn.

Flues Hollow pipes that pass through the tank of an asphalt distributor or heater-tank, to enable heat to be better dispersed through the middle of the tank. The burner flame is directed into the flues. Care must be taken not to allow the flues to get too hot, or the asphalt around the surface of the flues will burn.

Fog Seal A light application of sprayed asphalt applied on top of a pavement surface to seal out surface water. This is commonly used over a seal coat or over a new asphaltic concrete surface overlay.

Gates Hinged lids which are opened to allow aggregate to drop from the discharge hopper of an aggregate spreader onto a roller bar and be spread evenly over a film of asphalt sealer. The gates are adjustable to open wider and permit more aggregate to pass through or less widely to permit only a small amount of aggregate to be discharged. The gate adjustment is critical to an even distribution of cover aggregate.

Hopper Aggregate spreaders have two bins or hoppers. The receiving hopper is where the haul truck dumps the aggregate at the rear of the spreader. Conveyor belts transport the aggregate from the receiving hopper to the discharge hopper located at the front of the machine. From the bottom of the discharge hopper, the aggregate is spread evenly on the roadway.

Impermeability The property asphalt has to resist the passage of air and water through it. It is this property that makes asphalt an excellent sealer to prevent water and air from entering the base course or asphaltic concrete pavement. Water and air passing through a surface pavement and entering the base course will considerably shorten the pavement lift.

Penetration The distance a needle penetrates into asphalt, under a specified weight, in a specified time, and at a specified temperature. This is a controlled laboratory test.

Penetration Grading Is a classification system based on penetration for asphalt cements of 0.1 mm at 25°C (77°F). There are five standard paving grades, 40-50, 60-70, 85-100, 120-150, and 200-300.

Pneumatic Technically, this describes a type of tire that is filled with compressed air. Automobile and bicycle tires are of the pneumatic type. Some compaction equipment, having a number of rubber pneumatic tires to provide the compaction, are called pneumatic rollers or are often referred to as simply “pneumatics.”

Raveling The progressive separation of aggregate particles in a pavement. It begins at the top and works downward, or at the edges and works inward, until the aggregate has been totally dislodged. It may be caused by a lack of compaction, construction of a thin course during cold weather, dirty or disintegrating aggregate, not enough asphalt in the mix, or overheating the asphalt mix when it was manufactured.

Rollers Compaction equipment. Rollers either have pneumatic tires (from 7 to 9) or one or more cylindrical metal drums. On most modern rollers, their overall weight can be varied by adding ballast. Materials used for ballast are either wet sand, crushed rock, or water.

Sieve A series of metal pans with wire mesh screens replacing the solid bottoms. The openings in the screens are of specified sizes, to allow particles smaller than the opening to fall through. The screens are placed, one on top of the other, with the coarsest mesh screens on top, and decreasing in mesh size down to the bottom, which has the finest mesh. These are used to analyze the size of aggregate particles, which is called sieve analysis or screen analysis.

Skid Resistance The characteristic of a pavement surface that concerns the slippage or skidding of automobile tires on the pavement surface. The surface texture and shape of aggregate particles is important in resisting skidding or slippage. Rough textured and irregular shaped aggregate particles offer the best skid resistance. Aggregate particle should resist polishing smooth in order to retain the skid resistant property over long periods of time.

Special Provisions Special requirements for materials or services that must be provided on a construction project. These are usually requirements that are unique to only one project or situation. Special Provisions take precedence over Standard Specifications.

Specifications (Standard) Requirements for materials and services that serve as the minimum acceptable standards for construction of highways, streets, and bridges. In addition to Standard Specifications that apply generally to all construction, the plans for a given project may include Special Specifications.

TMA Truck Mounted Attenuator is an energy-absorbing attachment to a dedicated truck for use in work zones.

Unit Weight The actual weight of a known volume of material. Unit weight of aggregate to be used on a seal coat project must be determined in order to compute the application rate. Unit weight is usually measured with the aggregate as it comes from the stockpile, with a small amount of moisture content, to parallel realistic conditions.

Viscosity The resistance of a material to flowing. We refer to a fluid which is "thick" and highly resistant to flowing as a high viscosity fluid. Material with the consistency of water is low viscosity, since it flows easily. Asphalt, being a thermoplastic, will change viscosity as its temperature changes. As heat is added, its viscosity decreases and it flows more easily. As it cools, it becomes more viscous. Under laboratory conditions, the viscosity of asphalt is tested at 140°F.

APPENDIX B

CHARTS

APPENDIX B - ASPHALT AND AGGREGATE CHARTS

STORAGE TEMPERATURES FOR EMULSIFIED ASPHALTS

Grade	Temperature, °F (°C)	
	Minimum	Maximum
RS-2, CRS-1, CRS-2	125° (50°)	185° (85°)
SS-1, SS-1h, CSS-1, CSS-1h, MS-1, HFMS-1	50° (10°)	140° (60°)
CMS-2, CMS-2h, MS-2, MS-2h, HFMS-2, HFMS-2h	125° (50°)	185° (85°)

SUGGESTED DISTRIBUTOR SPRAYING TEMPERATURES FOR VARIOUS GRADES OF EMULSIFIED ASPHALT--DEGREES FAHRENHEIT (°F)*

Type and Grade of Asphalt	Spraying Temperatures	
	Road Mixes	Surface Treatments
Emulsified Asphalts		
MS-1	70-160	---
MS-2	70-160	---
MS-2h	70-160	---
HFMS-1	70-160	---
HFMS-2	70-160	---
HFMS-2h	70-160	---
SS-1	70-160	---
SS-1h	70-160	---
CRS-1	---	125-185
CRS-2	---	125-185
CRS-2LM	---	125-185
CRS-2P	---	125-185
CMS-2	70-160	---
CMS-2h	70-160	---
CSS-1	70-160	---
CSS-1h	70-160	---

JRS:Q:MTC:MTG-MAN:CHIPSEAL.kmc

GALLONS OF EMULSIFIED ASPHALT REQUIRED PER 100 LINEAR FEET
VARIOUS WIDTHS AND RATES

Gals. Per Sq. Yd.	WIDTH – FEET														
	1	**2**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**	**16**	**18**	**20**	**22**	**24**
0.10	1.1	2.2	6.7	7.8	8.9	10.0	11.1	12.2	13.3	15.6	17.8	20.0	22.2	24.4	26.7
0.15	1.7	3.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	23.3	26.7	30.0	33.3	36.7	40.0
0.20	2.2	4.4	13.3	15.6	17.8	20.0	22.2	24.4	26.7	31.1	35.6	40.0	44.4	48.9	53.3
0.25	2.8	5.6	16.7	19.4	22.2	25.0	27.8	30.6	33.3	38.9	44.4	50.0	55.6	61.1	66.7
0.30	3.3	6.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	46.7	53.3	60.0	66.7	73.3	80.0
0.35	3.9	7.8	23.3	27.2	31.1	35.0	38.9	42.8	46.7	54.4	62.2	70.0	77.8	85.5	93.3
0.40	4.4	8.9	26.7	31.1	35.6	40.0	44.4	48.9	53.3	62.2	71.1	80.0	88.9	97.8	107.
0.45	5.0	10.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	70.0	80.0	90.0	100.	110.	120.
0.50	5.6	11.1	33.3	38.9	44.4	50.0	55.5	61.1	66.7	77.8	88.9	100.	111.	122.	133.
0.55	6.1	12.2	36.7	42.8	48.9	55.0	61.1	67.2	73.3	85.5	97.8	110.	122.	134.	147.
0.60	6.7	13.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	93.3	107.	120.	133.	147.	160.
0.65	7.2	14.4	43.3	50.6	57.8	65.0	72.2	79.4	86.7	101.	115.	130.	144.	159.	173.
0.70	7.8	15.6	46.7	54.4	62.2	70.0	77.8	85.5	93.3	109.	124.	140.	156.	171.	187.
0.75	8.3	16.7	50.0	58.3	66.7	75.0	83.3	91.7	100.	117.	133.	150.	167.	183.	200.
0.80	8.9	17.8	53.3	62.2	71.1	80.0	88.9	97.8	107.	124.	142.	160.	178.	196.	213.
0.85	9.4	18.9	56.7	66.1	75.5	85.0	94.4	104.	113.	132.	151.	170.	189.	208.	227.
0.90	10.0	20.0	60.0	70.0	80.0	90.0	100.	110.	120.	140.	160.	180.	200.	220.	240.
0.95	10.6	21.1	63.3	73.9	84.4	95.0	106.	116.	127.	148.	169.	190.	211.	232.	253.
1.00	11.1	22.2	66.7	77.8	88.9	100.	111.	122.	133.	156.	178.	200.	222.	244.	267.
1.10	12.2	24.4	73.3	85.5	97.8	110.	122.	134.	147.	171.	196.	220.	244.	269.	293.
1.20	13.3	26.7	80.0	93.3	107.	120.	133.	147.	160.	187.	213.	240.	267.	293.	320.
1.25	13.9	27.8	83.3	97.2	111.	125.	139.	153.	167.	194.	222.	250.	278.	306.	333.
1.30	14.4	28.9	86.7	101.	116.	130.	144.	159.	173.	202.	230.	260.	288.	318.	347.
1.40	15.6	31.1	93.3	109.	124.	140.	156.	171.	187.	218.	249.	280.	311.	342.	373.
1.50	16.7	33.3	100.	117.	133.	150.	167.	183.	200.	233.	267.	300.	333.	367.	400.
1.75	19.4	38.9	117.	136.	156.	175.	194.	214.	233.	272.	311.	350.	389.	427.	467.
2.00	22.2	44.4	133.	156.	178.	200.	222.	244.	267.	311.	356.	400.	444.	489.	533.
2.25	25.0	50.0	150.	175.	200.	225.	250.	275.	300.	350.	400.	450.	500.	550.	600.
2.50	27.8	55.6	167.	194.	222.	250.	278.	306.	333.	389.	444.	500.	556.	311.	667.
2.75	30.6	61.1	183.	214.	244.	275.	306.	336.	367.	428.	489.	550.	611.	672.	733.
3.00	33.3	66.7	200.	233.	267.	300.	333.	367.	400.	467.	533.	600.	667.	733.	800.

Note: Formula used for calculation: $Q = \frac{100W}{9} R = 11.11WR$

For metric conversion factors see Table C-10

Where: Q = Quantity of asphalt required, in gallons per 100 ft. (l/m)
R = Rate of application in gallons per sq. yd. (l/m^2)
W = Width of application, in feet (m)

Metric formula for calculation:
Q = LWR where L = Length in meters

TONS OF AGGREGATE REQUIRED PER MILE FOR VARIOUS
WIDTHS AND RATES

Spread Rate	Spread Width (In Feet)						
	8	9	10	12	16	18	20
lb/yd^2	Tons Per Mile	Tons Per Mile	Tons Per Mile	Tons Per Mile	Tons Per Mile	Tons Per Mile	Tons Per Mile
5	12	13	15	18	23	26	29
10	23	26	29	35	47	53	59
15	35	40	44	53	70	79	88
20	47	53	59	70	94	106	117
25	59	66	73	88	117	132	147
30	70	79	88	106	141	158	176
35	82	92	103	123	164	185	205
40	94	106	117	141	188	211	235
45	106	119	132	158	211	238	264
50	117	132	147	176	235	264	293
60	141	158	176	211	282	317	352
75	176	198	220	264	352	396	440
100	235	264	293	352	469	528	587
150	352	396	440	528	704	792	880
200	469	528	587	704	939	1056	1173
250	587	660	733	880	1173	1320	1467
300	704	792	880	1056	1408	1584	1760

To Convert From	To	Multiply By
Feet	meters	0.3048
lb/yd^2	kg/m^2	0.542492
tons/mi	Mg/km	0.563698

AREAS PER MILE AND PER 1000 LINEAR FEET FOR VARIOUS WIDTHS

Width in Feet	Square Feet Per Mile	Square Yards Per Mile	Square Yards Per 1000 Lin. Ft.
1	5,280	587	111.1
2	10,560	1,173	222.2
3	15,840	1,760	333.3
4	21,120	2,347	444.4
5	26,400	2,933	555.6
6	31,680	3,520	666.7
7	36,960	4,107	777.8
8	42,240	4,693	888.9
9	47,520	5,280	1,000.0
10	52,800	5,867	1,111.1
12	63,360	7,040	1,333.3
14	73,920	8,213	1,555.6
15	79,200	8,800	1,666.7
16	84,480	9,387	1,777.8
18	95,040	10,560	2,000.0
20	105,600	11,733	2,222.2
22	116,160	12,907	2,444.4
24	126,720	14,080	2,666.7
26	137,280	15,253	2,888.9
28	147,840	16,427	3,111.1
30	158,400	17,600	3,333.3
32	168,960	18,773	3,555.6
36	190,080	21,120	4,000.0
40	211,200	23,467	4,444.4
50	264,000	29,333	5,555.6
60	316,800	35,200	6,666.7

To Convert From	To	Multiply By
Feet	meters	0.3048
ft^2	m^2/km	0.189394
yd^2/mi	m^2/km	0.337089
$yd^2/1{,}000$ ft	$m^2/300$ m	0.009144

TEMPERATURE CONVERSION CHART

Fahrenheit to Degrees Celsius									
°F	**°C**	**°F**	**°C**	**°F**	**°C**	**°F**	**°C**	**°F**	**°C**
-9	-23	31	-1	71	22	111	44	151	66
-8	-22	32	0*	72	22	112	44	152	67
-7	-22	33	1	73	23	113	45*	153	67
-6	-21	34	1	74	23	114	46	154	68
-5	-21	35	2	75	24	115	46	155	68
-4	-20*	36	2	76	24	116	47	156	69
-3	-19	37	3	77	25*	117	47	157	69
-2	-19	38	3	78	26	118	48	158	70*
-1	-18	39	4	79	26	119	48	159	71
0	-18	40	4	80	27	120	49	160	71
1	-17	41	5*	81	27	121	49	161	72
2	-17	42	6	82	28	122	50*	162	72
3	-16	43	6	83	28	123	51	163	73
4	-16	44	7	84	29	124	51	164	73
5	-15*	45	7	85	29	125	52	165	74
6	-14	46	8	86	30*	126	52	166	74
7	-14	47	8	87	31	127	53	167	75*
8	-13	48	9	88	31	128	53	168	76
9	-13	49	9	89	32	129	54	169	76
10	-12	50	10*	90	32	130	54	170	77
11	-12	51	11	91	33	131	55*	171	77
12	-11	52	11	92	33	132	56	172	78
13	-11	53	12	93	34	133	56	173	78
14	-10*	54	12	94	34	134	57	174	79
15	-9	55	13	95	35*	135	57	175	79
16	-9	56	13	96	36	136	58	176	80*
17	-8	57	14	97	36	137	58	177	81
18	-8	58	14	98	37	138	59	178	81
19	-7	59	15*	99	37	139	59	179	82
20	-7	60	16	100	38	140	60*	180	82
21	-6	61	16	101	38	141	61	181	83
22	-6	62	17	102	39	142	61	182	83
23	-5*	63	17	103	39	143	62	183	84
24	-4	64	18	104	40*	144	62	184	84
25	-4	65	18	105	41	145	63	185	85*
26	-3	66	19	106	41	146	63		
27	-3	67	19	107	42	147	64		
28	-2	68	20*	108	42	148	64		
29	-2	69	21	109	43	149	65*		
30	-1	70	21	110	43	150	66		

*These are exact conversions.

Examples: 25°F is –4°C (minus four degrees Celsius
78°F is 26°C; 107°F is 42°C

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TABLE C-1 TEMPERATURE – VOLUME CORRECTIONS FOR EMULSIFIED ASPHALTS

°C^t	°F	M*	°C^t	°F	M*	°C^t	°F	M*
10.0	50	1.00250	35.0	95	0.99125	60.0	140	0.98000
10.6	51	1.00225	35.6	96	0.99100	60.6	141	0.97975
11.1	52	1.00200	36.1	97	0.99075	61.1	142	0.97950
11.7	53	1.00175	36.7	98	0.99050	61.7	143	0.97925
12.2	54	1.00150	37.2	99	0.99025	62.2	144	0.97900
12.8	55	1.00125	37.8	100	0.99000	62.8	145	0.97875
13.3	56	1.00100	38.3	101	0.98975	63.3	146	0.97850
13.9	57	1.00075	38.9	102	0.98950	63.9	147	0.97825
14.4	58	1.00050	39.4	103	0.98925	64.4	148	0.97800
15.0	59	1.00025	40.0	104	0.98900	65.0	149	0.97775
15.6	60	1.00000	40.6	105	0.98875	65.6	150	0.97750
16.1	61	0.99975	41.1	106	0.98850	66.1	151	0.97725
16.7	62	0.99950	41.7	107	0.98825	66.7	152	0.97700
17.2	63	0.99925	42.2	108	0.98800	67.2	153	0.97675
17.8	64	0.99900	42.8	109	0.98775	67.8	154	0.97650
18.3	65	0.99875	43.3	110	0.98750	68.3	155	0.97625
18.9	66	0.99850	43.9	111	0.98725	68.9	156	0.97600
19.4	67	0.99825	44.4	112	0.98700	69.4	157	0.97575
20.0	68	0.99800	45.0	113	0.98675	70.0	158	0.97550
20.6	69	0.99775	45.6	114	0.98650	70.6	159	0.97525
21.1	70	0.99750	46.1	115	0.98625	71.1	160	0.97500
21.7	71	0.99725	46.7	116	0.98600	71.7	161	0.97475
22.2	72	0.99700	47.2	117	0.98575	72.2	162	0.97450
22.8	73	0.99675	47.8	118	0.98550	72.8	163	0.97425
23.3	74	0.99650	48.3	119	0.98525	73.3	164	0.97400
23.9	75	0.99625	48.9	120	0.98500	73.9	165	0.97375
24.4	76	0.99600	49.4	121	0.98475	74.4	166	0.97350
25.0	77	0.99575	50.0	122	0.98450	75.0	167	0.97325
25.6	78	0.99550	50.6	123	0.98425	75.6	168	0.97300
26.1	79	0.99525	51.1	124	0.98400	76.1	169	0.97275
16.7	80	0.99500	51.7	125	0.98375	76.7	170	0.97250
27.2	81	0.99475	52.2	126	0.98350	77.2	171	0.97225
27.8	82	0.99450	52.8	127	0.98325	77.8	172	0.97200
28.3	83	0.99425	53.3	128	0.98300	78.3	173	0.97175
28.9	84	0.99400	53.9	129	0.98275	78.9	174	0.97150
29.4	85	0.99375	54.4	130	0.98250	79.4	175	0.97125
30.0	86	0.99350	55.0	131	0.98225	80.0	176	0.97100
30.6	87	0.99325	55.6	132	0.98200	80.6	177	0.97075
31.1	88	0.99300	56.1	133	0.98175	81.1	178	0.97050
31.7	89	0.99275	56.7	134	0.98150	81.7	179	0.97025
32.2	90	0.99250	57.2	135	0.98125	82.2	180	0.97000
32.8	91	0.99225	57.8	136	0.98100	82.8	181	0.96975
33.3	92	0.99200	58.3	137	0.98075	83.3	182	0.96950
33.9	93	0.99175	58.9	138	0.98050	83.9	183	0.96925
34.4	94	0.99150	59.4	139	0.98025	84.4	184	0.96900

t = observed temperature in degrees Celsius (Fahrenheit)
M = multiplier for correcting volumes to the basis the 15.6°C (60°F)
* Multiplier (M) for °C is a close approximation

APPENDIX C

FORMS

MONTANA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
PO BOX 491
LEWISTOWN, MT 59457-0491

ROAD OIL ORDER FORM

VENDOR: Montana Refining Co
PO Box 1243
Great Falls MT 59403

FAX NUMBER: 761-0174
ATTN: ALAN L HOBBS
Phone: 761-4100

Purchase Order Number: HWY-304379

****

Order Placed By: James Stevenson

Date/Time of Order: July 24 7:30 AM

Phone: (406) 538-8731 FAX: (406) 538-3128

Product Ordered CRS-2

2 Loads

Quantity 7000 Gallons (NET) Additive: ____Yes ____No

Delivery Location: ROUTE JCT MT 80 + MILEPOST 81

DESCRIPTION 17 miles North of Stanford at JCT MT 80 + 81

DATE & HOUR DELIVERY TO TAKE PLACE: 7:30 AM + 9:50 AM July 25, 1995

IS A PUMP & HOSE EQUIPPED TRANSPORT NEEDED? ✓ YES ____NO

Special Instructions: Keller will haul one load with Distributor. Two Loads of 7000 Gallons (Net) TOTAL of 14,000 Gallons (Net)

****

Order Received By: Marcy Atkinson

Date/Time: 7-24-95, 9:10 AM

Please sign above when received and FAX CONFIRMATION copy back to the Department of Transportation-Lewistown 538-3128.

wp:roadoilfax

97

Montana Department of Transportation

CERTIFICATE OF COMPLIANCE

Vendor, by signing this document, certifies that product provided, as listed below, meets requirements established for said product within Montana Standard Specifications For Road and Bridge Design, most recent revision.

Vendor must complete A-O; designated trucker must complete P-T; Highway Department must complete U-V.

(A) VENDOR'S NAME: MONTANA REFINING COMPANY

(B) SHIPPED FROM: GREAT FALLS, MT (C) DESTINATION: Stanford MT

(D) DATE/TIME OF SHIPMENT: 7/25/95

(E) BILL OF LADING #: 0668

(F) TYPE AND GRADE OF PRODUCT: CRS-2 EMULSION

(G) ADDITIVE: _____ (H) SPECIFIC GRAVITY @ 60°F: 1.0113

(I) WT./GAL. @ 60°F: 8.4223 (J) LOADING TEMPERATURE: 180

(K) VISCOSITY: 150 - 400

(L) CONVEYANCE INFORMATION:
(1) TRUCK AND TRAILER AND (2) PUP TRAILER:

GROSS WEIGHT:	(1) 76540 / (2)	
TARE WEIGHT:	(1) 27960 / (2)	
NET WEIGHT:	(1) 48580 / (2)	
CAPACITY:	(1) / (2)	

(M) TONS TO GALLONS CONVERSION:
24.29 (NUMBER) TON(S) OF PRODUCT REPRESENTED BY THIS SHIPMENT AND BASED ON INFORMATION SUPPLIED ABOVE, EQUALS 5768 (NUMBER) GALLONS OF PRODUCT AT 60°F.

(N) INSPECTION OF CONVEYANCE: VENDOR CERTIFIES THAT THIS CONVEYANCE HAS BEEN INSPECTED AND FOUND TO BE FREE OF CONTAMINATING MATERIALS.

(O) VENDOR'S SIGNATURE: M. A. Zorn
Authorized Representative

DESIGNATED TRUCKER:
(P) NAME OF TRUCKING FIRM: Keller

(Q) DATE/TIME OF RECEIPT: _____

(R) RECEIPT TEMPERATURE: _____ (S) SAMPLE TAKEN: ____ YES ____ NO

(T) TRUCKER'S SIGNATURE: _____
Driver

TRANSPORTATION DEPARTMENT EMPLOYEE:
(U) THE UNDERSIGNED CERTIFIES THAT PRODUCT AS DESCRIBED HEREIN WAS OFFICIALLY RECEIVED IN GOOD CONDITION AND THAT A SAMPLE WAS/WAS NOT TAKEN IN A PROPER MANNER.

(V) EMPLOYEE'S SIGNATURE: _____ DATE _____

MONTANA REFINING COMPANY

No 7016

7-4 2319 9-6 C3

BOL # 0668

CUSTOMER: MT DEPT TRANSP LEWISTOWN.

7016 ID. NO.

27960 LB GR

22:06 23/07/95

PRODUCT: CRS-2

7016 ID. NO.

76540 LB GR

27960 LB TR RECAL

48580 LB NT

REMARKS:

01:50 24/07/95

DRIVER

MR-1000

No. 0668

ISSUED AT GREAT FALLS, MONTANA DATE 7-24-95

REFINERY OR TERMINAL AT MONTANA REFINING COMPANY ARRIVE DATE 9:30 AM 7-25-95

COMMODITY	APPROX GALS	COMM NO	LOADING INSTRUCTIONS PRODUCT	GROSS GALS
~~SS-1~~		1	FREIGHT COLLECT	
CRS-2		2	Freight Paid	
~~CMS-2S~~		3		

CUST. ORDER NO	SHIPPER'S ORDER NO	NO OF SEALS
	A-4245	

THIS IS YOUR AUTHORITY TO LOAD PRODUCT INTO TRUCK OR CARRIER A Hobbs

FREIGHT: PPD ___ COL XX

ICC PERMIT NO	STATE PERMIT NO	STATE UC NO	TRAILER NO	TIME IN

PRODUCE north of Stanford at Jet MT 80 & 81 — DESTINATION — TIME OUT

* TERM	DATE	SUPPLIER	TOWN	STATE
	7 25 95	MONTANA REFINING COMPANY - GREAT FALLS, MT.		

+ CUST NO - DEST	CONSIGNEE	DESTINATION - TOWN, STATE
	MT Dept of Transp., Lewistown, MT	

$ B/L NO	CUST ORDER NO	SHIPPER ORDER NO	CASH REC'D	SAMPLE NUMBERS
	PO 304-379-DT			

= CARR NO	GROSS CAP	F C	CARRIER NAME	TRLR NO	TK CALIBRATION NO
			Keller		

STATE UC NO	STATE PERMIT NO	ICC PERMIT NO	R R COMM "END NO	SEAL NO'S INC

CERTIFICATE OF COMPLIANCE

The shipment of material identified and covered by this B/L complies with specifications applicable to the above identified project for the type and grade of material represented and that the conveyance was inspected and found to be free of contaminating material.

MONTANA REFINING COMPANY BY _____

	GROSS GAL	NET @ 60°F	COMPT NO	GRAV	TEMP
~~SS-1~~ ASPHALT					

	GROSS GAL	NET @ 60°F	COMPT NO	GRAV	TEMP
~~CRS-2~~ ASPHALT		5768			150

WT, PER. 8.4223 GROSS. 76540

NET, WT. 48580 24,29 TARE. 27960

	GROSS GAL	NET @ 60°F	COMPT NO	GRAV	TEMP
~~CMS-2S~~ ASPHALT					

WEIGHT _____

	GROSS GAL	NET @ 60°F	COMPT NO	GRAV	TEMP
~~SS-1~~ Crs 2					

FOR CHEMICAL EMERGENCY, SPILL, LEAK, FIRE, EXPOSURE OR ACCIDENT
CALL CHEMTREC DAY OR NIGHT 800-424-9300

NAME OF ORDERING COMPANY — STATE

MT Dept of Tranp., Lewistown, MT

This order is placed with the understanding that I (we) assume full responsibility for delivery at destination shown and in no case will product be unloaded at any other point. Payment will be made in accordance with the applicable sales contract.

BY AUTHORIZED REPRESENTATIVE

FORM NO. #2 (REV. 4-85)

2 TRUCK LOADING ORDER NO. 2 COPY)

keller transport, inc.

Telephone 406-259-2202 • 1305 Taylor Place
Billings, Montana 59101

BILL NO. 106080

DATE 7-25-95

CLIENT CODE

MANIFEST NO.

TRUCK	%	PREP.	CO
2			

TRAILER NO.	LOADED	EMPT
562		

Appt: 9:30 A.M.

Arrival: 7:30

Depart: 10:30 A.M.

PRODUCT ORDERED

CRS 2

CODE	ORIGIN	CODE	DESTINATION	SHIPPER	CONSIGNEE
	GREAT FALLS MT.		STANFORD MT 17 m. No.	MONT. REFINING	MT. D.O.T.

COMP.	GALS.-LBS. DELIVER.	COMMODITY	CODE	GROSS GALLONS	LOADING TEMP.	NET GALLONS	RATE	CHARGES	TAX	TOTAL
		GASOLINE (FLAMMABLE LIQUID)	UN 1203 01							
		FUELS (COMBUSTIBLE LIQUID)	UN 1993 02							
		ASPHALT	NA 1999 03							
	48580	CRS2				5768				

CONSIGNEE BY:

DRIVER NO. 1

DRIVER NO. 2

Bozeman: 406-388-4910, Glendive: 406-365-3825, Missoula: 406-777-2571, Helena: 406-443-2666, Kalispell: 406-752-2109, Great Falls: 406-452-9713

INVOICE

74-2319 946 03

7503078

MONTANA REFINING COMPANY
501 EAST MAIN STREET
P O BOX 159
ARTESIA, NM 88211-0159

DATE: 07/25/95

PLEASE REMIT TO:
Montana Refining Company
P. O. Box 667
Great Falls, MT 59403-0667

SOLD: MONTANA DEPARTMENT OF TRANSP.
TO
P.O. BOX 491
LEWISTOWN, MT 59457-0491
025416

MAIL: MONTANA DEPARTMENT OF TRANSP.
TO
P.O. BOX 491
LEWISTOWN, MT 59457-0491
1% 10 Net 30

TERMS:
Net Due 30 Days From Inv Date

Cust Reference: Lewistown Dist

Federal ID# 74-2319946

SHIPPED
FROM: Great Falls, MT (MRC)

MOD: TT Contract: S-8600056

FOB: Dest

Description	Quantity	U/Price	Extensio
Shipped: 07/25/95			
REF: 668 Carr: Keller Transp Destn: Various Montana CRS 2 14245	24.29 TN N	119.560000	2,904.1

AUG. 0 4 PAID

RECEIVED
4529

08-02-95= 20,124.35

ROAD OIL	CODING INFO SDL 22437005301	MT REFNING 74-2319 946 03	PRICE/TON
MMS ACTIVITY NO. 8440 CREW: 5312	I certify that the items listed on this invoice have been received. DATE: 7-31-95 BY: Duane Hartman TITLE: MTC SUPT	125340 RSP 2738 EXPN 29% AMOUNT 1340 ACCT 65312 PROJ 5768 QTY 19 U/M P0304379	AC 85-100 119.56 AC 120-150 119.56 CRS-2 119.56 SS-1 119.56 24.29 TON X = GAL

LEWISTOWN, MONTANA

INVOICE TOTAL 2,904.1

Pay Invoice by 08/24/95.
Telephone: (505) 748-3311

7503078

CUSTOMER ORIGINAL

Keller Transport, Inc.
1311 Taylor Place
P.O. Box 30197
Billings, MT 59107

ROAD OIL DISTRIBUTOR INVOICE

No. 612 X

1496

DATE	DISTRIBUTOR NO.	PROJECT NO.	LOCATION OF PROJECT
7-25-95	204		Coffee Creek rst - West Hwy 81

CONSIGNEE	MILES FOR SHOOTING	CLIENT CODE
Montana DOT Lewistown District		98

TRUCK NO.	PRODUCT	GROSS GALLONS	TEMP.	SPREADING TIME START	SPREADING TIME FINISH	TOTAL HOURS SPREADING	TYPE OF SPREADING	NET WEIGHT	RATE	TOTAL AMOUNT
204	CRS-2	11892	186°	7:30 AM			Chip Seal	48,580		
	CRS-2				1:00 PM	5½ hrs	Chip Seal	51,578		
								100,158	11.50T	$575.91

AUG 19 PAID

CONSIGNEE	DRIVER	REMARKS
Dean Hartman	Walt Wyatt	

KELLER TRANSPORT, INC. BILLINGS, MT ROAD OIL 406-259-2202 or 1-800-544-4613

STATE OF MONTANA

DEPARTMENT OF HIGHWAYS

MAINTENANCE ROAD OIL DELIVERY CERTIFICATE

DIVISION Lewistown Purchase Order No. 304-379 DT

Name of Oil Company MRC Bill of Lading No. 06668

Type of Oil CRS-2 Additive (Yes) (No) _____ Sample Taken (Yes) (No) Yes

Date and time of arrival of transporter 7:30 July 25

Departure Time 10:30

Exact Delivery Point (or points, if split del.) _____

Unloading or other difficulties encountered, if any _____

White Copy to Refinery—Return with carrier
Pink Copy to Division Headquarters
Yellow Copy to remain in book
FORM 112—1SM TRIP.

By James Stevens
(Signature of State Employee Receiving Oil)

MONTANA DEPARTMENT OF TRANSPORTATION
ACTIVITY REPORT

MMS
MAINTENANCE MANAGEMENT SYSTEM

CREW NUMBER 5312 WEEK ENDING 071289 5

WORK DATE		WORK LOCATION			WORK DESCRIPTION				LABOR		EQUIPMENT										MATERIAL				SPECIAL
		ROUTE	MILEPOST								1ST CLASS			2ND CLASS			3RD CLASS			PRIVATE EQUIPMENT COST	1ST CLASS		2ND CLASS		
MONTH	DAY	SYSTEM NUMBER	BEGINNING MILEPOST	ENDING MILEPOST	ACCOUNT NUMBER	COST CENTER, PROJECT OR SPECIAL CODING	ACTIVITY NUMBER	WORK UNITS COMPLETED	NO. WORKERS	HOURS WORKED	STATE EQUIPMENT CLASS	USAGE HRS/MI.	ASSIGNED HOURS	STATE EQUIPMENT CLASS	USAGE HRS/MI.	ASSIGNED HOURS	STATE EQUIPMENT CLASS	USAGE HRS/MI.	ASSIGNED HOURS		CLASS	QUANTITY	CLASS	QUANTITY OR COST	
07	25	A				0653128440	11892	0	0	00													00	59.87	C
07	25	P	91	00	60	5396605	11063	3375	01	51	03	24	8	10	65	55	01	03	14	16	20	06	11892			L7
											10	02	15	10	29	45	33	30	29	45	32	30			
											07	14	75	30	09	07	04	50							

*PREPARED BY
(FIELD MAINTENANCE SUPERVISOR)

APPROVED BY
(FIELD MAINTENANCE BUREAU CHIEF OR SUPERINTENDENT)

SHEET___ OF___

MMS-70

LAB FORM NO. 101-C REV. 3-70

DEPARTMENT OF HIGHWAYS

Helena, Montana

ASPHALTIC MATERIALS REPORT

(Cost Center)
Project No. 5395600 Designation Arrow Creek

Name and Address of Contractor

Type and Mfg. of Material CRS-2 Montana Refining Co.

Type of Adhesive Agent Used

Sampled by James Stevenson Title Acl. Maint. Sup. Address Lewistown

Submitted by SAME Title SAME Address SAME

Date submitted July 25, 1995 Date received

Sp. Gr.

Identification Test Results

Lab No.	Field No.	Date Sampled	Invoice No.	Quantity	Viscosity	Penetration	Flash
	1	7-25-96	0676	7000			
	1A	7-25-96	0676	7000			
	2	7-25-96	0677	7000			
	2A	7-25-96	0677	7000			
	3	7-25-96	0678	7000			
	3A	7-25-96	0678	7000			

NOTE: You will need to take Two Samples from each load; label in the manner above (1 & 1A etc.). Continue the Consecutive number sequence until the Completion of the Project. Remember to start your numbering sequence over for each new project and Cost Center.

CHECKED AND APPROVED	DATE	TIME