# Dust Control on Unpaved Roads

Gravel and other unpaved surfaces can provide good, economical roads for low traffic volumes. The dust they produce, however, causes air pollution, slows plant growth, and damages the road surface. Although paving is the only permanent solution to dust problems, using effective controls can significantly reduce dust and can cut required maintenance.

Unpaved roads are the largest source of particulate air pollution in the country. According to the Environmental Protection Agency, unpaved roads produce almost five times as much particulate matter as construction activities and wind erosion (the next two largest sources) combined. In addition to polluting the air, dust can be a health problem for nearby residents. It also settles on plants up to 500 feet from the road edge, slowing their growth and reducing crop yields.

A single vehicle traveling an unpaved road once a day for a year will produce one ton of dust per mile, according to an Iowa study. This translates to losing 100 tons of fine particles a year for each mile of road with an average of 100 vehicles a day.

When these fines are lost as dust, it damages the gravel surface and exposes the larger aggregate pieces. These are then scattered by vehicles or washed away. The unstable road surface becomes rough, developing potholes and washboarding. These hold water which infiltrates and damages the base. In addition, the eroded material damages ditches and drainage systems. Repairs can be frequent and expensive.

Successful treatment can significantly reduce dust conditions and help preserve road surfaces. Studies show that control measures can reduce dust by 30% to 80% and cut aggregate loss by 25% to 75%. However, such treatments are temporary and repeat applications may be necessary.


***Dust is a major source of air pollution and degrades unpaved road surfaces.***

## Where and when to use dust control

Dust control measures can be relatively costly for their short life spans. It is best to apply them where they will be most effective and economical. Take into account the cost of materials and application, traffic speed, daily traffic counts, road structure, localized problems, and future plans for the road.

***Cost*** In evaluating costs, consider the price of the product to be applied, surface preparation costs, and application costs. You may save money by applying dust controls along just the center strip of the road and by spot-treating on a cost-share basis with roadside residents. Studies report that you can expect a 25% to 75% cost reduction in blading and re-graveling by using a dust control program.

***Speed*** The amount of dust produced is related to vehicle speed. Cutting average vehicle speeds from 40 mph to 35 mph will reduce dust emissions by 40%. However, applying dust control measures will usually be less costly and more effective than speed enforcement. Therefore, you may choose to use dust control on roads where vehicle speeds are higher.

***Traffic counts*** Extremely low volume roads probably do not justify the costs for dust control. Higher volume roads are too difficult to maintain with temporary dust control. The Transportation Research Board recommends you apply dust control on roads which carry between 15 and 500 vehicles per day on average.

***Road structure*** Dust control will be both helpful and cost effective on unpaved roads which are already in good shape — having proper crown, adequate drainage, a good mix of fines and aggregates, and a well-compacted surface. It will not solve problems caused by poor construction, bad drainage, or lack of maintenance. When the subgrade is granular with a high amount of fines, or when surface material has fines of less than 5% or more than 30%, dust control may work but will not be cost effective.

***Localized problems*** Spot treatment may be useful where dust is causing problems — near residences or at intersections, for example — even if the road does not meet other selection guidelines.

***Future plans*** Dust control may be useful when the gravel surface is a temporary stage before paving. Roads treated with calcium chloride have provided excellent subgrades for higher-class pavements.

## Selecting dust control agents

When selecting materials for dust control consider these basic requirements:

- environmentally compatible
- easily applied with common road maintenance equipment
- workable and responsive to maintenance
- reasonably effective at controlling dust
- not degrading to ride quality
- relatively harmless to vehicles using road
- posing little hazard or inconvenience to adjacent residents
- cost competitive

The most common dust control agents are chlorides, asphalt products, and lignin. The accompanying chart gives details on these products. The general characteristics of these and other treatments used for dust control are described here.

### *Chlorides*

Calcium chloride and magnesium chloride are the two most commonly used dust control agents (75% to 80% of the time). These *hygroscopic* (water attracting) agents increase the moisture content of the surface by attracting moisture from the atmosphere. This helps form a crust and hold the road fines into the aggregate surface. In addition, calcium chloride retards the evaporation of moisture and tightens the compacted soil, strengthening the road. These inorganic chemicals are environmentally safe and fairly economical. While their performance depends on temperature, relative humidity, and traffic, the effectiveness generally lasts 6 to 12 months. Sugar beet extract, another hygroscopic agent, has also been used for dust control.

*Calcium chloride* is corrosive to vehicles and application equipment, and can create a slippery surface when applied. Because it is soluble in water, it is easily leached away. When dissolving solid calcium chloride to make your own liquid, be very careful of the tremendous heat that is generated.

A mix of 50% calcium chloride and 50% regular road salt (sodium chloride) can be an economical way to extend the benefits of calcium chloride. Sodium chloride provides some stabilization of the aggregate surface and the calcium chloride controls dust.

*Magnesium chloride* has many of the same advantages and disadvantages of calcium chloride. It is more sensitive to temperature, needing temperatures above 70° F and relative humidity above 32% to be effective. Magnesium chloride tends to create a harder surface than calcium chloride but you need 18% to 20% more material to produce comparable results.

### *Asphalt and lignin*

Petroleum products and lignin sulfonate (a residue of paper production) are the other major group of commonly used dust control agents. These are *adhesives and binders* that physically glue soil particles together. These products, which are used about 20% of the time, form a hard crust. They are also waterproof which helps stabilize soil. In this category are also organic and petroleum resins, vegetable oils including soybean soapstocks, and hybrid products like a bitumen-lignin mix.

*Asphalt emulsions* can work on a broad range of soil types and are very good at waterproofing an aggregate surface. They do cause tracking of the asphalt which can be nuisance for auto owners and nearby residents. Periodic re-grading of the road tends to be more expensive and more difficult when it has been treated with asphalt.

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Some proprietary emulsion products for dust control have been developed. One, Coherex, has a documented history of good performance in Minnesota and can be very cost-effective for spot locations.

*Lignin sulfonate* is a waste product from wood pulp digestion processes. The untreated material, also called red liquor, sulfite liquor and a variety of other names, has traditionally been used for dust control by rural towns located near paper mills. While it is still available, paper mills now are using a variety of other recycling and disposal methods to manage it.

The untreated material is highly acidic, foul-smelling when spread, and very sticky, clinging to vehicles. Complaints are common because of these problems, so be sure to give advance warning to residents and businesses before you treat their roads with sulfite liquor.

Dried, processed lignin sulfonate, which is available commercially, does not have these problems but costs more than the untreated material which is usually supplied free. Research shows that lignin sulfonate does not negatively affect ground and surface water when established guidelines are followed during spreading.

To produce a hard surface, lignin must be worked into the top one or two inches of the aggregate, usually after the road surface has been worked by equipment. It can be useful on surfaces where the aggregate mix has a very low fine content (4%-8%). It is diluted by heavy rains and becomes slippery when wet and very brittle when dry. Repeat applications will be needed because the lignin will decompose over time.

### *Other materials and treatments*

Products like lime, fly ash, Portland cement, and bioenzymes, are *cements* which work by permanently gluing together finely divided soil particles through chemical reaction.

*Stabilizers* work by entering into the natural electrochemical reactions between soil particles. Ammonium chloride, sulfonated naphthalene, and some enzymes have been used as clay stabilizers. Bentonite, a naturally occurring sodium montmorillonite clay, has been used to stabilize limestone roads in Iowa, proving to be an effective and less costly alternative to calcium chloride.

*Physical treatments* are also used. These include installing geotextiles and spreading milled recycled asphalt (RAP) to produce a dust-free aggregate surface.

Pulverized or milled asphalt pavement produces a good quality gravel surface. The residual asphalt has a tendency to hold down dust and compact together to form a hard surface. It may require an additional surface treatment, such as a sealcoat, because the resulting surface is very porous. Under heavier traffic conditions, including stopping and turning, the recycled asphalt surface may not have enough stability to resist rutting and raveling. Its performance will depend on the amount of residual asphalt, the extent of aging in the asphalt, and the effectiveness of the grading and compaction.

## Applying dust control agents

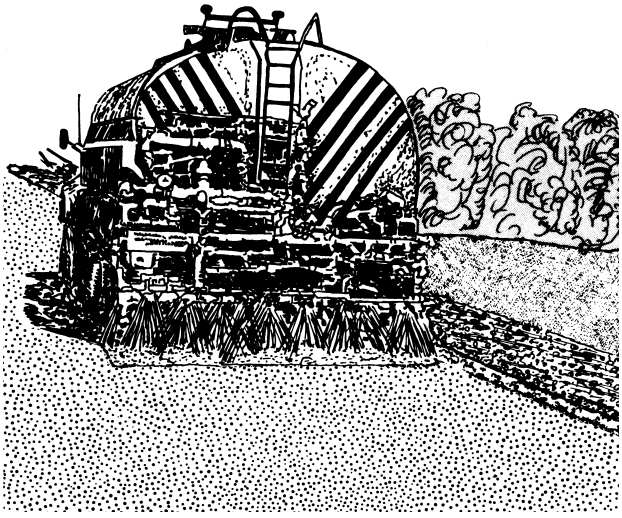
Prepare the road surface first. Blade away all ruts, potholes, washboards, and loose excess surface material to expose a hard surface. You may need to add moistened aggregate or fines to ensure proper compaction. Fines may be bladed from shoulders onto surface. Recycled asphalt can also be used as a source of aggregate when sufficient fines are present. Make the additions in layers, blending with existing material.

Shape the road surface into a proper crown of 1/2 inch per foot. If normal traffic will not adequately compact the road, use a rubber-tired roller to compact the bladed and shaped surface.

Since standing water is the main cause of potholes and road base failure, reshape shoulders to promote runoff, clean ditches for good drainage, and clean and repair culverts. (Be sure to follow erosion control guidelines during ditching and to close the soil surface immediately afterwards.)

### *Spreading chlorides and other penetrating agents*

Make the initial application in spring before dust coat develops and when no heavy rain is expected for at least 36 hours. Temperatures should remain above 40° F. Use the recommended application rates from the table. Reduce the amount by half for roads which have been treated previously.



***When applying liquid calcium chloride, overlap the centerline which carries the most traffic. Avoid runoff or puddling. If areas are left uncovered by poor driving of the distributor, stop and add water before beginning to spread again.***

| Dust Control Agent | Attributes | Limitations | Applications | Sources |
|---|---|---|---|---|
| **Calcium Chloride** | Starts to absorb water from air at 29% relative humidity (77° F) ◆ Reduces rate of evaporation 3.4 times. The vapor pressure of saturated solution is 77 mm Hg at 77° F. The lower the vapor pressure, the greater the ability to resist evaporation. ◆ Significantly increases surface tension of water film between particles, helping to slow evaporation and further tighten compacted soil as drying progresses. ◆ Lowers freezing point of water solution to -60° F, minimizing frost heave (30% solution). Freezing of treated road not only begins at lower temperature but is gradual and seldom completed. ◆ Treated road can be regraded and recompacted with less concern for losing moisture and density. | Slightly corrosive to steel and highly corrosive to aluminum and its alloys. Prolongs corrosion period because it attracts moisture. ◆ Rainwater tends to infiltrate and leach out highly soluble chlorides. On roads with proper crown, most water is deflected sideways into ditches. ◆ During dry periods, upward capillary action may cause chlorides to crystallize near road surface where they can be leached away by sudden rain. ◆ Low cementing action. Effective dust control only with well-graded, stable road mixes. ◆ Releases heat as it dissolves—enough to be a safety hazard to workers mixing the dry form in water. ◆ Spills of concentrate may kill or burn vegetation. Reasonable care in handling required. ◆ Should not be spread over bridge decks. Spills must be cleaned quickly to prevent slick spots. | Typically 2 treatments per year.<br>***Initial:***<br>Flake — 1.0 to 1.5 lb./sq. yd.<br>Pellet — 0.8 to 1.3 lb./sq. yd.<br>Liquid — 0.2 to 0.3 gal./sq. yd.<br>***Follow-up:*** 1/2 to 2/3 initial dosage<br>Can be stored in buildings, hoppers, silos, or covered piles. Must be airtight and protected from wet, humid conditions. Storage floor at ground level should be paved asphalt or treated concrete. Gravity feed systems require 45° for flakes to flow, 35° for pellets. *Wisconsin statutes require dry calcium chloride be stored covered on an impermeable base.* ◆ Be cautious of tremendous heat released when mixing with water. ◆ Spread by tank trucks with pressure distributors and spinner disk or positive-displacement units. | Byproduct brine from manufacture of sodium carbonate by ammonia-soda process, and of bromine from natural brines.<br>***Three forms:***<br>*Flake or Type I:* 77%-80% conc., 100 lb. bags<br>*Pellet or Type II:* 94%-97% conc., 80 lb. bags<br>*Clear liquid:* 32%, 35%, 38% conc., tankers<br>***Brand names:***<br>LIQUIDOW, DOW FLAKE, PELADOW, SUPERFLAKE |
| **Magnesium Chloride** | Starts to absorb water from air at 32% relative humidity (77° F). ◆ Reduces rate of evaporation 3.1 times (vapor pressure of saturated solution is 7.6 mm Hg at 77° F). ◆ Increases surface tension more effectively than calcium chloride solutions. Results in very hard road surface, reducing maintenance costs. ◆ Lowers freezing point of water solution to -27° F (22% solution). Freezing of treated road not only begins at lower temperature but is gradual and seldom completed. ◆ Treated road can be re-graded and recompacted with less concern for losing moisture and density. | In concentrated solutions, very corrosive to steel. Prolongs corrosion period because it attracts moisture. Some products may contain a corrosion-inhibiting additive. ◆ Rainwater tends to infiltrate and leach out highly soluble chlorides. On roads with proper crown, most water is deflected sideways into ditches. ◆ During dry periods, upward capillary action may cause chlorides to crystallize near road surface where they can be leached away by sudden rain. | Typically 2 treatments per year.<br>***Initial:*** 30% solution at 0.5 gal./sq. yd.<br>***Follow-up:*** 1/2 initial dosage. Storage and handling same as for liquid calcium chloride. ◆ Applied preferably with pressure spray bars as splash bars apply unevenly. ◆ For follow-up dosage, can use grader with scarifer blade to incorporate. When adding new gravel to road, can blade-in in two passes at 0.25 gal./sq. yd. each pass before spreading gravel. | Occurs naturally as brine (evaporated); also byproduct of potash production. ◆ Usually liquid form, 25%-35% solution.<br>***Brand names:*** DUSTGARD, DUS-TOP |
| **Bitumens, tars, resinous adhesives** | Binds soils because of asphalt's adhesive properties. ◆ Waterproofs road. ◆ May be adapted to suit wide range of soils, gravels, and traffic conditions. | Under dry conditions may not maintain resilience. Can form a crust and fragment under traffic loads. ◆ *Waste oil use prohibited in Wisconsin.* ◆ Material cost significantly higher than for other chemical suppressants. | Generally 1-2 treatments per year. ◆ 0.1 to 1.0 gal./sq. yd. depending on road surface condition and dilution. ◆ Sprayed using many types of equipment — hand-held hoses to asphalt distributors.<br>** Note: MC and RC grades may only be used for dust control during May and September in Wisconsin.* ◀ | Tars (coal residues) and bitumens (crude oil residues) combined with water and emulsifier or lighter fractions of distillate; wide range of viscosities.<br>***Liquid asphalt:*** Grade SC-70, SC-250, MC-70, MC-250 *<br>***Bituminous emulsions:*** Grades SS-1, SS-1h, CSS-1, or CSS-1h mixed with 5+ parts water by volume.<br>***Brand names:*** COHEREX |
| **Lignin sulfonate and processed lignin products** | Greatly increases dry strength of soil similar to 3 in. of asphalt concrete. Under dry conditions out-performs bituminous binders. ◆ During rain, disperses clay which in turn swells and plugs pores, reducing water penetration. ◆ Tends to stay slightly plastic, permitting reshaping and additional traffic compaction. ◆ Addition of calcium carbonate slurry to counteract corrosive effects reduces solubility, prolonging dust-laying capability. ◆ Ammonium-based sulfite liquors are superior to sugar-free calcium-base sulfides for aggregate binding. ◆ Variable material cost. Unprocessed liquors usually free; processed prices vary with timber prices. | Control depends on well-graded soil-aggregate mix, loosened to a depth of 1-2 inches just prior to initial applications. Silt and clay content of wearing surface needs to be 4-8%. ◆ If unprocessed material is used, high acidity may cause corrosion of aluminum and its alloys. ◆ Surface binding action may be reduced or completely destroyed by heavy rain owing to solubility of solids content in water. ◆ Slippery when wet; brittle when dry. ◆ Temporary strong odor. ◆ Potential to discolor paint or other surfaces when splashed on vehicles. ◆ Unprocessed lignin is very odorous and sticky. | Generally 1 to 2 treatments per year.<br>10%-25% solution at 0.5 to 1.0 gal./sq. yd.<br>***Powder:*** 1.0 to 2.0 lb./sq. yd.<br>Application methods same as for chlorides. *Application is regulated in Wisconsin.* Contracts from suppliers include application requirements. ◆ In Wisconsin, application is restricted near dwellings and water wells and along surface waters. | Water liquor of papermaking industry. Contains lignin (the natural cement that binds wood fibers) and carbohydrates in solution. Also called sulfite liquor, red, black, or green liquor, sulfite lye, ammonium lignin sulfonate, calcium lignosulfonate. ◆ Composition depends on raw materials (mainly wood pulp) and chemicals used to extract cellulose; active constituent is neutralized lignin sulfonic acid containing sugar. ◆ 20% sugar content recommended. ◆ Combination lignin-bitumen products may be available.<br>***Brand names:*** LIGNOSOL, NORLIG, RAY BINDER |

***Spreading chlorides*** *continued from page 3*

Pre-wet the surface with water at rates ranging from 0.03 to 0.3 gal./sq. yd. to reduce surface tension, to develop the capillary action that allows maximum penetration of the dust control product, and to ensure uniform application. If a dust coat has already developed, regrade and moisten.

Choose dry calcium chloride for smaller applications. The bags are easy to store and the dry material requires less specialized equipment to apply. Store dry calcium chloride covered on an impermeable base. Wisconsin statutes require proper storage. Liquid calcium chloride, which is less expensive, easier to handle, and easier to apply, is best for larger projects.

Apply calcium chloride or other agent evenly over the road's surface. The applications should overlap each other by 6 to 12 inches, and should overlap the crown at the center of the road which carries the most traffic.

Follow dry applications with enough water to ensure that the pellets or flakes are completely dissolved. When applying liquids, avoid runoff or puddling. Use several light sprays if the surface is tight. If areas are left uncovered by poor driving of the distributor, stop and add water before beginning to spread again. If penetration is poor, you may need to use a mix-in-place procedure.

Allow the treated road to cure up to four hours — until vehicles can drive on the road without picking up treated material on their wheels. Curing may take longer on roads with finer grained materials. If necessary, compact the treated area after curing is completed.

Treat the road a second time before the first one becomes totally ineffective. Make the second treatment in late summer or early fall if the first was in the spring. Apply about half as much calcium chloride as the first time and reblade as necessary.

*Special application procedures for sulfite liquors*
Sulfite liquor application rates have to be controlled by the spreader operator to eliminate ponding on the road surface and to prevent any runoff into surface water or wetlands. If in doubt, the operator should shut off application of liquor 300 feet or more before and after reaching culverts, stream crossings, bridges, wetlands, etc. Sulfite liquor should also not be applied to frozen or impervious surfaces or on any paved road surfaces.

## *Mixing in place*

When penetration is poor or you are applying products to help stabilize the base, you will need to mix the agent in place on the road. This process is recommended for applying untreated lignin sulfonate. As with spreading, be sure to properly shape crown, shoulders, and ditches to promote drainage.

Scarify the top one to two inches of the road to loosen the aggregate. Prepare the surface by removing potholes and washboards and adding any necessary aggregate or fines. Mix thoroughly scarified materials using a pulverizer. It may take several passes to break aggregates down to sizes less than 1.5 inches. Moisten the surface with from 0.03 to 0.3 gal./sq. yd. of water. Re-mix scarified materials after watering, to ensure optimum moisture content.

Apply the dust control agent uniformly. Use longitudinal blade mixing coupled with rotary mixing by the pulverizer. Add water as necessary.

Blade the mixture into a windrow along one edge of the road, then spread the windrow in two equal lifts. Each lift should be compacted with a sheepsfoot roller until the tamping feet "walk out." Finally, blade the mixture for crown and compact it with a rubber-tired roller. Allow the mix to cure long enough to prevent excessive pickup from traffic.

## *Maintenance for calcium chloride-treated road*

During dry periods, water the road periodically to reactivate the chemical's hygroscopic properties. Apply water at the rate of 0.1 to 0.2 gal./sq. yd.

Usually only a light blading is needed, preferably after a rainfall. Studies show that maintenance can be cut by 25% to 75% on calcium chloride-treated roads.

The grader should blade lightly from edges toward the center and then feather the material back toward the edges. It is a good practice to blade in short sections so the area can be compacted before it dries out. Blading in dry conditions is not recommended as it can loosen aggregate and dissipate calcium chloride.

## *Asphalt application and maintenance*

Prepare the road surface, reshape crown, and clean ditches and culverts before applying asphalt products.

Use a diluted, slow setting asphalt emulsion (SS-1h, or CSS-1h), or a cutback (SC-70, SC-250, MC-70, or MC-250). (Note that cutback use is restricted in Wisconsin. See below.) Use lower viscosity products on unpaved roads with tightly bonded surfaces, such as silt-clay, or on aggregate roads with a silt-clay binder. Use higher viscosity asphalts for loose, open, coarse-grained road surfaces.

Apply at a rate of 0.1 to 0.5 gal./sq. yd. Use only as much asphalt as can be absorbed in about 24 hours. Slightly damp surfaces will absorb more material than very dry surfaces. The tighter the surface, the lower the recommended application rate. Dilution rates are normally from 1:1 to 2:1 with higher dilution rates for tighter surfaces.

*Continues on back panel, page 6.*

Roads with higher traffic volumes usually require more asphalt for effective dust control than roads with lower traffic volumes. Roads treated for the first time tend to require more asphalt than those that have been treated in previous years. Initial seasonal treatments also tend to require more asphalt than treatments applied later in the same season.

Splashing on vehicles which drive over the newly treated surface can be a drawback to using asphalt for dust control. Lightly sand, blade, or drag the road after asphalt treatment to prevent this tracking. Use about 5 to 10 pounds of sand per square yard of road surface.

Unpaved surfaces can be hardened through successive applications of asphalt over several years. A thin surface layer is built up which reduces dust problems but may make it more difficult to blade and regrade the road. If successive applications are planned, apply a total of 0.75 to 1.0 gal./sq. yd. of emulsion or cutback in three applications. Use about half the total for the first application and divide the remaining amount between the second and third applications. Leave enough time between applications for the road surface to completely absorb the asphalt.

To maintain an asphalt-treated road, patch with cold mix or hot mix asphalt pavement or gravel. If you use gravel, it should be coated with asphalt to make it hold to the road surface.

### *Restrictions on asphalt cutbacks and waste oil*

Cutback use is restricted in Wisconsin. Medium-curing and rapid-curing cutbacks may not be used for any purpose during June, July and August. They may be used for dust control (or as a prime coat before asphalt surfacing) during May and September. All other uses of these cutbacks are prohibited during these months. Slow-curing cutbacks are not restricted.

Do not use waste oil for dust control. Waste oil often contains harmful contaminants and must be managed as a hazardous substance under state law.

## References and resources

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