ENVIRONMENTAL EFFECTS OF APPLYING LIGNOSULFONATE TO ROADS

By

JAMES W ADAMS

DAISHOWA CHEMICALS INC
Research & Development

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SUMMARY:

The overall impact on the environment from applying lignosulfonates to roads is negligible. They are safer to use for stabilisation and dust control than any competing class of chemicals.

The manufacture of lignin involves evaporation; the evaporation process drives off any volatile contaminants such as acetic acid. Corrosion and toxicity towards plants can be readily minimised by pH control and lignosulfonates are non-toxic to animals.

Lignosulfonates have been applied to roads, used in animal feeds and converted into human foods for more than 30 years without problem. This comes as no surprise after learning that the products have the following properties:

- No dioxins present. No other organics present at hazardous levels
- Toxic trace minerals are below EP Toxicity limits *
- Low order of toxicity towards fish
- Non-toxic orally and non-irritating to the skin or eyes of animals
- No human health problems attributed to exposure
- Very low toxicity towards plants
- Residuals are resistant to decay

When spread on land, there is no risk of contaminating ground water. Published data indicate that at less than 10 kgs per square meter, no problems arise. This is much above the 1 kgm/square meter required for stabilisation and 0.3 kgm used for dust control.

The non-hazardous features and abundant supply of lignosulfonate make it a good material for treating roads (1). It is widely used in Sweden and California – two of the world's most environment-conscious areas.

PRODUCTION:

In the sulfite pulping of wood, lignin – nature's binder – becomes soluble and is separated from the pulp fibers as spent liquor (SSL). This liquor also contains the naturally occurring wood sugars.

Dilute SSL at 12% solids is treated and concentrated to 50 – 60% solids by evaporating water. Starting from this base material, a family of chemicals has been developed. They are known as lignins or lignosulfonates. They are used in the following applications:

Water Treatment Chemicals	Oil Well Drilling Mud Additives
Components of Adhesives	Textile Dye Dispersants
Animal Feed Pellet Binders	Gypsum Dispersants for Wallboard
Concrete Additives	Leather Tanning Agents
Road Binders	Dispersants for Brick Clay
Feed Molasses Additives	Battery Plate Expanders

** As set by the U.S. Environmental Protection Agency*

Of the 1.32 million tons of lignosulfonate sold worldwide, 150,000 tons are sold for application to roadways – 80,000 tons in North America and 70,000 tons in Europe and Australia. The product used on roads is the base product that has not been chemically modified and may be the calcium,

sodium or ammonium form depending on the pulp mill (36). Complex lignofsulfonates are sophisticated, high technological content chemicals, showing all the chemical complexity of the naturally occurring lignin from which they were derived.

SUGARS:

The types of sugars present in lignofsulfonate will change depending on the kind of wood pulped. Wood from needle-bearing trees yield predominantly the hexoses-mannose, glucose and galactose. Wood from leaf-bearing trees yield predominantly the pentoses-xylose and arabinose. We do not pulp maples!

ENVIRONMENTAL EFFECTS:

(a) Dioxins:

During the evaporation of spent liquor, SO_2 and any volatile components are removed. However, with attention recently focused (38) on the presence of dioxins in paper mill effluents, the U.S. Environmental Protection Agency approved laboratory – Enseco Inc., was contracted to determine the dioxin content of SSL roadbinder. Results from analysing a 7-day composite of Lignosol B, (a calcium lignofsulfonate) (37) show that it contains no detectable amounts of 2, 3, 7, 8 – tetrachloro dibenzofuran or 2,3 7, 8 – tetrachloro dibenzo-p-dioxin. This is not surprising as chlorinated organic contaminants require the presence of substantial chlorine concentrations. This can come from:

- Using chlorinated biocides after bleaching
- Bleaching fibers with chlorine, hypochlorite or chlorine dioxide

But the Quebec mill (REED) does not bleach. Mills that do bleach only do so after the lignosulfonate has been separated and removed from the system.

(b) Trace Elements:

Lignosulfonates are wood extracts that contain the mineral elements naturally present in trees. Depending on the tree type and soil on which it was grown, the wood contains different kinds and amounts of minerals. Element analysis of tree barks that are typical for plant residues were published by Harder and Einspahr (12).

The U.S. Environmental Protection Agency (EPA) has recently defined the maximum concentration of elements to establish EP Toxicity (5). Limits are shown in Table 1.

TABLE I.

MAXIMUM CONCENTRATION OF CONTAMINANTS FOR CHARACTERISTIC OF EP TOXICITY

EPA Hazardous Waste No.	Contaminant	Maximum Concentration, ppm
D004	Arsenic	**5.0**
D005	Barium	**100.0**
D006	Cadmium	**1.0**
D007	Chromium	**5.0**
D008	Lead	**5.0**
D009	Mercury	**0.2**
D010	Selenium	**1.0**
D011	Silver	**5.0**

REED's lignosulfonate products are submitted periodically for Proton Induced X-ray Emission analyses. The testing procedures can detect all eight of the EP Toxicity contaminants plus 67 others. Results on REED products (7) are reported in Table II. Note that barium, cadmium, mercury, selenium and silver could not be detected. The other EP Toxic elements are present at levels below the maximum concentration.

TABLE II.

TRACE ELEMENTS IN LIGNOSULFONATES

Reed Calcium Lignosulfonate

	Concentrate	Neutralized Concentrate
	ppm in solids	
Titanium	5.6	-
Aluminum	-	-
Silicon	105	241
Phosphorus	540	516
Manganese	118	155
Iron	207	869
Cobalt	1.8	6.6
Nickel	0.9	1.4
Copper	2	1.2
Zinc	25	31
Gallium	0.3	-
Bromine	0.7	0
Rubidium	3.7	2.5
Strontium	32.5	34
Zirconium	1.8	1.6
Molybdenum	0	2.5
Arsenic	0.1	-
Barium	-	-
Cadmium	-	-
Chromium	-	2.7
Lead	-	0.3
Mercury	-	-
Selenium	-	-
Silver	-	-

Neutralisation adds some trace minerals as they are contributed by the naturally occurring limestone that is used in the neutralising process.

ACUTE ANIMAL TOXICITY:

During the past 22 years, many of REED LIGNIN'S products have been examined. All of them proved to be non-toxic. Table III shows the results for 18 widely used products. The basic lignin used on roads would be even more innocuous (22).

To assess health risks involved in handling a new chemical, it is tested for acute toxicity in white rates and skin and eye irritation on rabbits. If all 10 rats in a test survive a one-time feeding dose of five grams/kilogram of body weight, the product is considered non-toxic according to the Occupational Safety and Health Administration (OSHA) rule, printed in the U.S. Code of Federal Regulations 29 CFR 1910.1200 (4). If rats do not survive the five gram/kilogram feeding level, testing is conducted to find the dose that kills 50% of the rats (LD_{50}).

Emperical scores are used to report results for skin and eye irritation tests with a skin irritation score of less than five needed to rate a material non-irritating to the skin. Testing for eye irritation is done following instructions in the Code of Federal Regulations 16 CFR 1500.42. The Hazelton Laboratory report on testing the lignin product, Additive-A Type 3, (10), is typical for doing this kind of work.

TABLE III

ACUTE TOXICITY OF LIGNIN PRODUCTS
TYPICAL REED PRODUCTS

PRODUCT	TEST LAB	DATE	ORAL TOXICITY ON WHITE RATS, LD_{50} g/kg	RABBIT SKIN IRRITATION INDEX	RABBIT EYE IRRITATION SCORE		
					24 hrs	48 hrs	72 hrs
Maracell XE	WARF	1977	> 5	0	0.33	0	0
Marasperse N-22	WARF	1975		0	0	0	0
Marasperse CB	WARF	1975		0	0	0	0
Marasperse CE-22	WARF	1977	> 5	0.17	2.0	0	0
Marasperse B-22	WARF	1975		0	0	0	0
Marasperse OS	Raltech	1978	> 5	0	0	0	0
Marasperse N-3	Raltech	1978	> 5	0	0	0	0
Marasperse CBOs-3	WARF	1977	> 5				
Marasperse CR-23-7	WARF	1977	> 5	0.21	0.67	0	0
Marasperse XCB-2	WARF	1977		0.17	0.67	0	0
Norlig 41	WARF	1975		0	0	0	0
Norlig 41d	WARF	1975		0	0	0	0
Norlig 41N	WARF	1976	> 5	0	0	0	0
Norlig 412	Raltech	1978	> 5	0.2	0	0	0
Additive-A, Type 3	Hazelton	1985	> 5	1.5	0	0	0
Americo SD-1	Raltech	1978	> 5	0	0	0	0
Kelig 32	WARF	1977		0	0	0	0
Kelig 32-2	Raltech	1978	> 5	0.1	0	0	0

Reed's roadbinder is among the Norlig 41 class of products.

SUBACUTE TOXICITY:

In 1960, American Cyanamid, Hercules Powder, NOPCO Chemical and Socony Mobil Oil Companies sponsored a study at the Industrial Bio-Test Laboratories to Determine the 90-day subacute oral toxicity of a REED sodium lignosfulfonate, Marasperse N.

Seven groups of 14 white rats were fed chow containing 0, 0, .01, .05, .20, 1.0 and 5.0% Marasperse N for 90 days. Results were reported by Kay and Calandra (15).

- None of the five dietary levels of Marasperse N had adverse effects on the growth of rats
- Only small differences were found for food consumption and food utilisation
- No dose-correlated trends were apparent in mortality data
- No significant abnormal behaviour was noted among animals of any group
- Periodic blood studies disclosed no adverse findings
- Urine analysis revealed no significant abnormalities
- No significant gross pathological findings were noted at autopsy of sacrificed animals

CHRONIC TOXICITY:

For effects of long-term exposure there are the good health records for those who have worked with reacting and spray drying this material. Over a period of 40 years to date, no human health problem has been attributed to exposure to lignosulfonate.

Before using lignosulfonate in poultry and animal feeds, calcium, sodium and ammonium forms of SSL were scrutinised very carefully for long-term health effects. Results of studies conducted to get approval to use the SSL products in animal feeds were obtained from the U.S. Department of Health & Human Services under the Freedom of Information Act (25). After reviewing data filed with Food Additive Petitions No. 706 and 1239, the Commissioner of the Food & Drug Administration ruled on August 15, 1962 that:

> "…….The Division of Food concludes that the product is reproducible, of uniform composition, and that it accomplishes its intended technical effect of pellet binding. An analytical method is available for regulatory purposes.
>
> The Division of Pharmacology concludes that use of the additive in animal feed under the proposed conditions of use in animal feed is safe.
>
> The Division of Veterinary Medicine concludes that the additive is safe for use in animal feeds and effective as a pelleting aid.
>
> Mr Philbeck, Meat Inspection Division, ARS, U.S.D.A., offers no adverse comment to this order."

Today, 30 years after lignins were introduced into animal feeds, no chronic toxicity problems have arisen. This is not surprising, after all – hay, grain and forage contain 20% lignin.

FISH TOXICITY:

Because a lot of water is needed for transporting, processing and pulping wood, paper mills locate near oceans, lakes and rivers. Many studies have been conducted to measure the water polluting effects of the following:

- Wood transport
- Debarking
- Pulping
- Fiber washing
- Fiber bleaching
- Paper making (6, 20, 21, 31, 32)

But, most of the studies have been concerned with spent liquor prior to evaporation, whereas lignosulfonate products, sold for road dedusting are SSL concentrates. When removing water in evaporators sulfur dioxide, acetic and formic acids are distilled off leaving liquors that are less toxic than the raw material. Published information about various lignosulfonates are summarised in Table IV along with reference toxicity values for familiar products.

Evaporating water and volatiles from dilute calcium and sodium SSL substantially reduces toxicity to the point where fish can tolerate 3,000 rather than 1,000 mg/l of solids. With purified lignosulfonates the tolerance is increased to 7,000 mg/l (27). The common salts calcium chloride, sodium chloride and sodium sulfate have LC_{50} 96-hour values in the 5,000 – 10,000 range (8). In reference books (18,28) the cutoff point for LC_{50} 96-hour values is 1,000 mg/l. Compounds with values greater than this are given a value of >1,000 and are considered to have a low order of toxicity. Calcium and sodium lignosulfonates, calcium chloride, sodium chloride and sodium sulfate all are in this category. By contrast, the popular laundry detergent **Tide** and surfactants used in making such products are very toxic toward fish (14). Values ranging from 4 – 50mg/l are reported for these materials in Table IV.

TABLE IV

TOXICITY OF WATER SOLUBLE MATERIALS TOWARD FISH

REFERENCE	FISH	LIGNOSULFONATE TESTED	LC_{50} – 96 hours mg solids/litre
Wilson	Rainbow Trout	Lignosol BD (Quebec)	3,700
Stapanian	Rainbow Trout	Lignosite (West Coast)	2,125
Wilson	Rainbow Trout	Lignosol XD	3,500
Roald	Rainbow Trout	Purified Na Lignosulfonate	7,300
Canada	Various	Calcium Chloride	5,000
Jones	Various	Sodium Chloride	6,000
Jones	Fathead Minnows	Sodium Sulfate	9,000
Jones	Fathead Minnows	**Tide** Laundry Detergent	50
Jones	Fathead Minnows	Sodium Dodecylbenzene Sulfonate	4
Jones	Fathead Minnows	Sodium Lauryl Sulfate	5

PLANTS:

With any liquid material that is applied to roadways, there is concern about harming plants that grow near the roads. Treating dirt roads with lignosulfonate to stabilise them for carrying vehicle traffic requires mixing 15 tons of solid per mile in the top six inches of soil on a 24-foot wide road. To do this, lignosulfonates are diluted with water. After spraying on the roadway, a road grader or scarifier is used to mix the binder with soil. Compacting with a roller is done soon after mixing.

For dust control, only 2.5 tons of solids per mile are sprayed on premoistened dirt roads. This total amount is usually applied in two applications.

In recent years both techniques have been used in Europe and North America. They account for the sale of 150,000 short tons of lignosulfonate solids that are used to treat 20,000 miles of roadway. No complaint of plant damage has been reported from this wide exposure (30). This is not a surprise after reading details of a very bold experiment that Stapanian and Shea (29) conducted. They applied Lignosite, a 50% solids calcium lignosulfonate, directly to the ground cover of Douglas Fir plantations in the state of Washington. Very high application rates of 21, 42 and 63 tons of solids per acre were applied to twelve 5 x 10m (16 x 33 feet) plots of forest land. Four plots received the same treatment. These treating levels are way above the 5 and 1.3 tons of solids per acre applications used for stabilising and dedusting roads.

Observations made periodically up to 12 weeks after the Lignosite was applied, indicated that the woody vegetation was not affected. The biomass of herbaceous plants was significantly decreased only at the two highest application rates. The growth of Douglas Fir trees was not significantly affected.

In another study Gast and Early (9) reported on the phytotoxicity of three commercial lignosulfonates toward garden crops, cotton and tobacco. This work was done with ingredients used for pesticide formulations. Of the 77 products tested, Marasperse C, Marasperse CB and Marasperse N were the least toxic. Pertinent results are reproduced in Table V. Lignosulfonates are now widely used in herbicide and pesticide formulations.

Chlorides are not expensive in California and, like lignins, are often used for dust abatement. However, at relatively low dosage chlorides can kill vines and care is suggested when applying them (19).

TABLE V

PHYTOTOXICITY RATINGS
Plant Injury

0 = None, 1 = Slight, 2 = Moderate, 3 = Heavy, 4 = Severe

Plant	Conc in Water Applied %	Marasperse C (Calcium Lignosulfonate)	Marasperse CB (Sodium Lignosulfonate)	Marasperse N (Sodium Lignosulfonate)
LEAVES				
Bean	1.0	0	1	0
	0.1	0	0	0
Corn	1.0	0	0	0
	0.1	0	0	0
Cotton	1.0	0	0	0
	0.1	0	0	0
Cucumber	1.0	0	0	0
	0.1	0	0	0
Tobacco	1.0	0	0	0
	0.1	0	0	0
Tomato	1.0	0.5	0.3	0
	0.1	0	0	0
ROOTS				
Tomato	1.0	4	1	4
	0.1	0	0	0
	0.01	0	0	0
	0.001	0	0	0
Tobacco	1.0	0	0	0
	0.1	0	0	0

GROUNDWATER:

The effect of lignosulfonate on groundwater is related to concentration. Applying 4,000 tons of dissolved solids each year to the same acre of porous soil will drive the liquor down into the groundwater with no time for destruction by fermentation. Results from ponding studies are vivid demonstrations. With much more modest one-time applications of 20 – 60 tons / acre Stapanian (29) indicates slow movement and time for fermentation which should pose no threat to contaminating groundwater. With no serious groundwater contamination expected at 50 tons/acre, applying 5 and 1.3 tons/acre for road paving and dust control would not be a serious matter.

DECAY / BIOLOGICAL OXYGEN DEMAND:

Sugars and carbohydrates are easily fermented by many different microbes. With as much as 35% of these easily fermented substances present in lignosulfonate, and few toxic materials around, it is no surprise that partial decay occurs quickly. In fact, lignosulfoante is used as a fermentation media for the commercial production of ethyl alcohol, fodder yeast and food-grade yeast.

Because of the wood sugars, lignosulfonates are not added to waterways containing fish and a marginal supply of dissolved oxygen. Microbes will feed on the sugars and consume oxygen in the process.

Results of many tests on basic lignosulfonate indicate that its five-day Biochemical Oxygen Demand (BOD_5) is 0.23 pounds per pound of solids. Microbes acting on 100 pounds of basic lignosulfonate for five days require 23 pounds of oxygen. The 100 pounds of lignin must be mixed with 394,000 gallons (1,500 cubic meters) of water containing 11 ppm dissolved oxygen to wind up after five days with water containing 4 ppm dissolved oxygen. The 4 ppm dissolved oxygen is where fish kill first appears. This means that 30 ppm of SSL solids will allow dissolved oxygen at a safe level. More complex lignosulfonates show lower BOD_5 values.

During the 1960s, much attention was given to laundry detergents that produce voluminous and persistent foam in discharge waterways. The problem was traced to sudsing surfactants that biodegraded very slowly. In developing new sudsing surfactants, River Dieaway was the most popular test used for measuring biodegradation. The test was applied to examine lignosulfonates.

Small amounts of lignosulfonate, dissolved in aerated Wisconsin River water, were held at room temperature for 33 days. Samples removed periodically were tested for organic matter content by oxidising with dichromate to determine the Chemical Oxygen Demand (COD). Data showed that Norlig A, a lignosulfonate roadbinding material, degraded 28% in five days and 43% in 33 days. This closely corresponds to the carbohydrate content of the product, and indicates that pure lignin resists decay. Pure lignin is the last to go in natural decay processes.

The 54% material remaining after 33 days of incubation persists as a roadbinder, and will show as natural lignin colour in waterways. It is a situation much like the brown colour imparted to streams and lakes by humus and humic acids produced in the decay of plants and trees.

CORROSION:

Severe corrosion of automobile underparts is usually associated with the use of salts for de-icing roads during winter months. This is not always so. A study by the Swedish Highway Department (17), indicates that in areas where calcium chloride or magnesium chloride is used for keeping dust down on dirt roads, automobile corrosion from this source is more severe than from salts used for road deicing(16).

Because of the nature of their binding mechanism, lignins absorb onto soils and clays and form cohesive bonds. This is very different from calcium chloride which is loosely concentrated on the surface of the road from where it is easily blown into passing vehicles where it can start its insidious corroding activity.

DISCUSSION:

This survey of lignin and the environment has only touched on the subject. However, a full reference index is attached for those wishing to study the subject in greater depth.

Any open minded analysis of the data will conclude that the use of lignin for dust control and road stabilisation is not only environmentally safe, but is more “environmentally friendly” than any other dust palliatives available.

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DUSTEX, AU 2004

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DUSTEX - FOR UNPAVED ROADS

WHY CHOOSE DUSTEX FOR DUST & ROAD STABILISATION?

Dustex, our premier dust control product, has been developed specifically for road stablisation and dust control applications. Dustex is a unique binder which offers the following benefits:

- Is compostible and biologically friendly
- Prevents wind erosion
- Reduces road-water usage by up to 90%
- Significantly reduces maintenance costs
- Increases the load bearing capacity of existing road materials

Dustex carries no environmental «baggage». This ligno-sulphonate based product is derived from a renewable and sustainable resource, plantation timber, and has absolutely no effect on flora or fauna when applied to roads and other dusty surfaces. Rather, Dustex is an environmentally beneficial product, reducing dust exposure for humans and animals and eliminating dust coverage of roadside foliage. Dustex is non-toxic and not harmful for humans or animals.

Problem Surface

Treated Surface

HOW DOES DUSTEX FUNCTION?

An important property of lignosulphonates is their ability to act as binders. The binding action of lignosulphonates is both chemical and physical in nature and results from the intermolecular forces between the sulphonated lignin molecules and the molecules on the surface of the particles being bonded. The size of the adhesive molecule is important for the formation of the cohesive bond and is also partly responsible for the strength of the cohesion. The bond is strong enough to resist the abrasion of tyres.

Lignosulphonates are effective binders for different types of soils and road aggregates and as such are not material specific. As a binder it glues the particles together and the treated surface layer becomes stiff, preventing individual particle movement and the subsequent generation of nuisance dust. The treated surface is smooth and hard with excellent traction in both wet and dry conditions.

PRODUCT APPLICATIONS

Dustex can be applied as a spray-on/surface application or as a mix-in treatment. Surface applications can be divided into two groups:

1) Non trafficable broad acre applications

2) Municipal and mine haul road applications

Broad acre applications

Dustex is applied to treat mineral dumps, construction sites, quarries, race tracks, open fields and virtually any area where the incidence of nuisance dust inhibits safe and efficient operations.

This simple surface application is the easiest and most cost effective way to achieve a dust-free environment and it is more effective than multiple applications of water, which is a scare commodity in many areas.

Dustex is best applied as an aqueous solution under pressure through spray nozzles, although it may also be applied under gravity with equipment as simple as a hose. A water cart equipped with a pump and spray bar is ideal.

For protection against wind erosion the minimum recommended thickness of the treated surface layer is 3-5 mm and for protection against wind erosion and moderate dynamic loads, 10-15 mm. Compaction further improves performance.

The application method is simple. Water the surface of the target area and apply the Dustex solution at the recommended rate of 1–1.5 litre per square meter. A Dustex application of 80–120 grams per sqare meter will consolidate most types of mineral and humus material for up to six months. There are many variables, which may influence this procedure and the rate of application and strength of the Dustex mixture should be adjusted to suit. The treatment should be repeated when the surface starts to dust again.

Municipal and Mining Haul Roads

To apply Dustex to roads, blade the road, ensuring an adequate camber and side drainage. Next, dampen the road with water to assist penetration. The application rate will depend on the moisture content of the road. Apply Dustex in a minimum of six applications over a period of three weeks and make sure to avoid puddling and runoff. On mining haul roads, deviations and construction sites, Dustex should be applied at a rate of 0.1kg/m^2 as part of the normal watering program until dust reduction is evident. The intervals between spraying will increase as the Dustex takes effect, but will be site-specific depending on drainage, traffic volumes and ambient dust levels.

ROAD STABILISATION - «MIX-IN» TREATMENTS

The Dustex «mix-in» method is used to bind and stabilise a layer with a thickness between 50 and 200 mm. The lignosulphonate glues the particles together, eliminating the individual particle movement, which results in surface deterioration and dust. The product is incorporated into the road material during the water binding process using conventional road making equipment or a high-capacity road stabiliser.

The quantity of Dustex required is between one and three percent of the weight of the material to be bound (calculated as dry matter on dry aggregate). The material to be bound should have a good particle size distribution and contain a minimum of eight percent of fines. The maximum aggregate size should be 20 percent of the target stabilisation depth.

To apply Dustex:

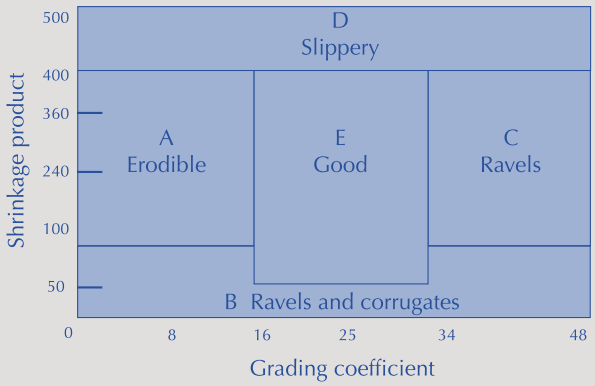
1. Rip the road to a depth and break down lumps with a rotivator. If regravelling, it is important to thoroughly mix the in situ material and the imported gravel before dumping into a windrow.
2. Spray the recommended concentration of Dustex solution and mix it thoroughly with a windrow. It is important the Dustex is evenly distributed.
3. Lay back material and compact using a roller.
4. Shape the road with a camber to ensure adequate drainage.
5. A slurry coat of a diluted Dustex solution may be applied as a surface seal. It is important to apply this surface application while the road is still damp.

MAINTENANCE AND REJUVENATION

- The type and frequency of maintenance will depend on the material characteristics, climate, application method and traffic, and should be carried out before significant deterioration has occurred.
- In cases of isolated deformation, Dustex can be mixed with aggregates and compacted into the effected area.
- If grader maintenance is required, the road must be sprayed with water, and then bladed according to accepted techniques. Do not dry blade as it will damage the road surface and lower the riding quality.
- Deleterious material on the sides of the road must not be bladed onto the road as this will result in potholing, dustiness and slippery conditions after rainfall.
- «Dustex-treated» roads will require periodic maintenance. The frequency of the treatments will depend on the material characteristics, application method, climatic conditions and traffic.
- Yearly maintenance applications are recommended. Dustex should be sprayed onto a dampened road surface after the road has been shaped and graded.
- Mining haul roads require more frequent maintenance treatments. An application of 40 grams per square meter of a dilute Dustex solution is recommended.

Material Selection

Dustex will perform effectively on a wide range of materials and is not material type specific. However, the formation of typical defects (e.g. erosion, corrugation, raveling, potholes, slipperiness) related to the use of inappropriate materials or poor construction and maintenance practices may be retarded but will probably not be prevented. The predicted performance of non-conforming materials is illustrated in the adjacent figure.



dustex

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Our highly skilled & dedicated research and development teams have extensive technical expertise in lignin technology. We strive for continuous improvement of our existing product lines, as well as the development of new solutions to meet our customers' needs.

EUROPE/AFRICA/MIDDLE EAST
Borregaard LignoTech
P.O.Box 162
N-1701 Sarpsborg, NORWAY
Tel. +47 69 11 81 78
Fax. +47 69 11 87 90
marketing_europe@borregaard com
www.borregaard.com

AMERICAS
LignoTech USA Inc.
721 Route 202/206
Bridgewater, NJ 08807 USA
Tel. +1 908 429 6660
Fax. +1 908 429 1112
marketing_americas@borregaard.com

ASIA-PACIFIC
Borregaard S.E.A PTE LTD
89 Science Park Drive #04-25
Singapore 118261
Tel. +65 6778 0008
Fax +65 6778 9800
marketing_asia.pacific@borregaard.com

AUSTRALIA
Dustex Australia PTY LTD
Applecross, WA 6953,
AUSTRALIA
Tel. +08 9330 1268
Fax. +08 9330 3825
dustex@q-net.net.au
www.dustex.com.au

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- Berms and swales
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- Sub-base road stabilisation
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