fluence test correlations and amounts of nutrients required, it is not surprising that adequate field experimental information is seldom available. Until such data are available, the interpretation of test results and the recommendations of how much nutrient to add should be made by someone with a good knowledge of soils and soil fertility.

Knowledge of the soils being tested, the nutrient requirements of the crops grown, and the effect of various factors on nutrient availability under different conditions permits extension of the available information to various situations for which adequate data are not available. Lack of such knowledge may lead to errors in recommendations.

When properly interpreted, tests of nutrient availability in soils can be used to predict yield increases to be expected from nutrient applications. This is basic information the farmer needs, but he must also consider other factors before he can reach a logical decision as to how much of the nutrients to apply.


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**Soil Reaction and Liming**

K. Lawton and L. T. Kurtz

A farmer in the Midwest who plans to grow alfalfa probably will have his soil tested because he knows that alfalfa grows poorly or not at all in strongly acid soils.

But when he selects ornamentals to landscape his home he might find the soil not acid enough to grow acid-loving plants like azaleas.

He knows generally that most of the common field crops grow well in slightly acid soils: When he limes to grow alfalfa he will have favorable soil reaction for corn and soybeans.

But many soils of humid areas naturally are too acid for the maximum production of many field crops. Many crops and plants grow best only if the soil reaction is suitable. Adjustment of soil acidity to the proper level often is important in good management.

Liming to reduce soil acidity is an extensive and routine practice in most of the eastern half of the United States. Soil acidity develops gradually in humid regions as the calcium and magnesium are slowly lost from the soil by leaching and is speeded by crop removals and by use of the soil.

Soils in the western Great Plains and in dry regions usually are neutral or slightly alkaline, rather than acid. Liming there is seldom necessary and often is harmful. The natural high-lime condition in some places contributes to nutritional disorder and poor production of some crops. Lime-induced chlorosis of fruit trees is an example.

Location is not a sure indication that
a soil needs lime. Although soils of the Eastern States generally need liming, the degree of acidity varies, and scattered areas of naturally calcareous soils—neutral to moderately alkaline—occur from Florida to Iowa. They may be a result of calcareous soil material or perhaps are shelly-spots associated with ancient lakes or marshes.

Many soils naturally are extremely acid, and only poor yields of field crops can be obtained on them even if fertility is adequate. They need moderate liming to correct soil acidity for maximum yields of corn and small grains.

Additional liming to a slightly acid or neutral range is necessary for maximum yields of other crops, particularly alfalfa and some other legumes.

Besides their value as crops, legumes are associated with nodule bacteria (rhizobia) and so can supply much of the nitrogen needed by following crops. Liming then influences the legume crops and also nitrogen fertility.

Before nitrogen fertilizers were readily available on the market, legumes were necessary in almost all systems of farming. Fixation through legumes was the one way to add nitrogen to the soil. Liming to encourage good growth of legumes used to receive more attention than now.

Availability of nitrogen from sources other than legumes should not detract very much from emphasis on the need for lime. Liming has been recommended for some sections on a fairly scientific basis for 50 years, but half of the acreage in these areas would still benefit from liming.

**Benefits from liming** result from more than mere reduction of soil acidity. Two major plant nutrients, calcium and magnesium, are supplied by liming materials. Soils that have too little calcium and magnesium for best plant growth often are highly acid. Liming may supply calcium and magnesium and correct the soil acidity at the same time.

Calcium and magnesium are removed in crops in large amounts, and those removals, along with leaching, contribute to the gradual development of acidity, a normal soil process in humid areas.

Finely ground limestone is the liming material used in many sections. Calcium carbonate is the active agent in limestone for reducing soil acidity. The calcium carbonate reacts with and neutralizes the soil acidity. The calcium then becomes part of the soil supply that can be utilized by plants.

Dolomitic limestone contains magnesium carbonate and calcium carbonate and therefore supplies magnesium, another nutrient. Even some of the high-calcium limestones contain significant percentages of magnesium.

Basic slag, a byproduct of the steel industry, is an important liming material in some regions, particularly in the Southeast. Calcium silicate is the active ingredient in the neutralization. Marl and chalk are soft, impure forms of limestone and are sometimes liming materials.

Oyster shells, in which the neutralizing agent is calcium carbonate, also are used.

Hydrated lime and burned lime, which contain calcium hydroxide and calcium oxide, are effective but usually are more expensive and are not applied very extensively. They supply little magnesium.

**Other benefits**, besides neutralizing soil acidity and supplying nutrients, may result from liming.

Regulation of soil acidity is a means of controlling some crop diseases. An example is potato scab, which is less severe in acid soils.

Liming influences the solubility of many compounds in the soil. Large amounts of iron, aluminum, and manganese may come into solution in a strongly acid soil and may be adsorbed on the surface of the soil particle in a form that plants can easily take up. Sometimes high levels of easily soluble manganese and aluminum are believed to be toxic to crops—a condition that liming can correct.
Liming influences the form of phosphorus in the soil. Phosphates are believed to react in highly acid soils with the active iron and aluminum to form complex substances. Calcium is the dominant ion on the surface of the soil particle in properly limed soils, and the phosphates apparently can be utilized more readily. In alkaline soils, phosphates react with the surface of calcium carbonate particles and crops utilize them less readily.

Myriad bacteria, fungi, and other kinds of micro-organisms abound in fertile soils. Some of the organisms are active in the decay of crop residues and manures in the soil. Decay processes release some of the nitrogen, phosphorus, and other mineral nutrients from these residues for subsequent crops. The activity of the micro-organisms and consequently the phosphorus and nitrogen fertility generally increase when an acid soil is limed.

The solubilities of iron, manganese, phosphorus, copper, zinc, and boron generally are less in alkaline soils than in slightly acid soils. But molybdenum is more soluble in alkaline soils than in acid soils, and liming may result in increased uptake of this micronutrient by crops. Some concern that liming may cause a deficiency of some nutrients or a toxic excess of molybdenum is probably warranted for a few soils.

Liming to adjust the soil to a slightly acid or near-neutral reaction will not induce deficiencies of phosphorus or
SOIL REACTION AND LIMING

2. A line dividing the humid from the subhumid sections indicates where soil processes tend to develop acid soils.

...the micronutrients in most soils and cropping situations. Underliming is far more common than overliming. If a deficiency of boron or phosphorus is induced by recommended applications of lime materials, the soils probably were already near the borderline and would soon have needed phosphate or borax fertilizers anyway.

Excessive liming should be avoided, of course. Overliming is less likely on silt or clay soils than on sandy soils. Medium-textured and heavy-textured soils of the middle States have a high capacity for lime. Sandy soils and highly weathered soils have low capacities and are more easily overlimed. Soil organic matter also has a high capacity for lime.

Frequency of liming varies with climate, soil, and cropping practices. Soils of heavy texture may require re-liming only once in 10 years. Applications on other soils should be made oftener. The need for re-liming—like the need for initial liming—can best be determined by testing the soil.

The acidity in most soils is on the surface of the soil particles. An acid soil should not be thought of as a mixture of inert soil particles in a solution of dilute acid. The acid ions stick almost completely to the surface of the soil particles.

This ability to hold cations on the particle surfaces resides chiefly in the clay, fine silt, and organic matter. Coarser particles have little ability to hold cations in this exchangeable form.

The exchange capacity of a soil under natural conditions is occupied with ions of hydrogen (acid), calcium, magnesium, potassium, and sometimes sodium. If a large proportion of the exchange capacity is occupied by hydrogen, the soil is acid and liming is needed. Liming will be unnecessary if a high proportion of the exchange capacity is occupied by calcium and magnesium.

This exchange capacity of many soils in nature is more than half-filled with acid ions. Such soils are extremely acid. Liming materials furnish calcium and magnesium to replace and neutralize the acidity.

A liming material must neutralize the hydrogen and furnish calcium and magnesium. Calcium sulfate (gypsum) supplies calcium but is not effective as a liming material. The carbonates or silicates of calcium and magnesium are effective because the activity of the acid is essentially eliminated in the reaction between the liming materials and the soil acidity.

In a well-limed agricultural soil, about 80 to 90 percent of the exchange capacity is ordinarily occupied with calcium plus magnesium; there are about 5 to 10 times as many calcium ions as magnesium ions. Potassium may be expected to occupy 2 to 5 percent of the capacity, and hydrogen (acid) the rest. Critical values for the balance among these ions have not been set, although normal ranges are well established.

To assist in determining needs for lime and fertilizers, soil-testing laboratories are operated in every State through the agricultural experiment stations and extension service. Soil-testing services also are available from many private companies and consulting services. Tests to indicate the lime needs of farm soils and recommendations for method and time of application are made.

Methods of sampling, costs of testing, and operations vary in different States, but the county agent or local extension representative has information for ob-
Annual Losses of Calcium and Magnesium From Soil by Leaching

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Calcium (Pounds per Acre)</th>
<th>Magnesium (Pounds per Acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAYBROOK</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>MUSCATE</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>CISNE</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

3. The mineral composition of crops varies widely from the amounts given here because of crop maturity of the crop and differences in soils, varieties, climate, and seasons. Ratios between the grain and nongrain portions of the crop also vary.

While the color of the indicator may change in color, the color may be yellow in acid soils, green in neutral soils, or blue in slightly alkaline soils. Mixtures of dyes are prepared to give enough color change so that several steps of acidity can be read. Indicators have been formulated in liquid or powder or impregnated in paper strips.

The determination of the pH does not give a direct measure of the amount of exchangeable acidity but only the "free" or ionized acidity. Therefore pH must be interpreted by the soil technician to make a recommendation of an amount of lime. Soils containing considerable clay and organic matter need more lime than do sandy or highly weathered soils of the same pH level. Texture and organic matter content consequently are often taken into account when making recommendations for lime. Sometimes the type of clay also is considered.

Methods have been designed to measure all of the exchangeable acidity. The soil sample is allowed to react with a solution that is especially formulated to react with the soil acidity.
amount of acid released from the soil to this buffer solution can be measured and expressed as the amount of limestone needed.

A method of this type was developed by C. M. Woodruff, of the University of Missouri, and is used in many soil-testing laboratories in this country. The buffer solution, when mixed with the soil, lowers in pH by one-tenth of a unit for each half ton of lime required by the soil. In the laboratory, the soil sample is mixed with the solution and allowed to stand while the reaction takes place. The electrodes of the Missouri Limemeter are then placed in the mixture of the soil and buffer and the amount of limestone needed per acre is read from that instrument. The Missouri Limemeter is a special type of pH meter for use with this procedure.

In Arizona, Colorado, Idaho, New Mexico, North Dakota, South Dakota, Utah, and Wyoming, the lime requirement is not determined routinely on soil samples because only rare soils are sufficiently acid to need liming.

Farmers and growers in most sections usually can buy a number of forms of lime. Each material neutralizes soil acidity, supplies calcium, and leaves no harmful residue in the soil. In this sense, calcium sulfate (gypsum) and calcium chloride do not qualify as liming materials even though they are more soluble forms of calcium than those considered as lime.

The selection of a liming material generally is based on its availability, the price per unit of calcium and magnesium, convenience in handling, and (in special cases) its rate of reaction with soil or its magnesium content.

The capacity of a liming material to neutralize soil acidity is expressed as its neutralizing value (N.V.), usually in terms of calcium carbonate as 100.

Because of the existence of forms of lime other than carbonates and the presence of impurities, the neutralizing value of commercial liming materials may run below 50 percent and as high as 200 percent.

Most high-calcium limestones and other natural forms of lime have neutralizing values between 75 and 95 percent. When appreciable amounts of magnesium carbonate (N.V. 119 percent), calcium hydroxide (N.V. 135 percent), calcium oxide (N.V. 178 percent), or magnesium oxide (N.V. 250 percent) are present, the neutralizing value of the lime source will be greater than 100 percent.

All liming materials can be classified in four forms, including carbonate, oxide, hydrate, and silicate compounds of calcium and magnesium. Ground limestone makes up more than 95 percent of all lime used in the United States, but a number of other liming materials are quite satisfactory.

This group of materials includes slag, marl, chalk, shells, and certain refuse and byproduct limes. Many of them occur naturally and are relatively inexpensive near their source.

Limestone is a sedimentary deposit. In rock form it consists of calcium and magnesium carbonates. It is widely distributed over the United States, and surface formations can be quarried and crushed rather easily. Limestone therefore is by far the commonest and one of the cheapest sources of lime. Deposits that consist almost entirely of calcium carbonate are called calcitic limestone. Those that contain magnesium carbonate up to almost 50 percent are referred to as dolomitic or high-magnesium limestone. As a rule, the dolomitic material has a higher neutralizing value, is a harder stone, and does not decompose so rapidly in acid soils as calcitic limestone. If these materials contain less than 80 percent by weight of calcium carbonate equivalent, they are considered low grade.

Marl is calcium carbonate that was deposited through chemical precipitation of calcium or by the biological action of certain aquatic plants and shell-forming animals in shallow lakes and swamps. It generally occurs as a soft, earthy, or mushlike material in layers or beds a few inches to many feet thick and overlying sand, clay, or areas
of peat or muck. Small amounts of magnesium carbonate and quantities of clay, sand, and organic matter may be present in marl. The neutralizing value of a good marl is considered to be 90 to 95 percent on a dry basis. As a rule of thumb, 2 cubic yards of marl is equivalent in neutralizing soil acidity to a ton of ground limestone. Deposits in Michigan, Wisconsin, Minnesota, Ohio, Washington, and other States generally contain considerable moisture and must be excavated with power shovels, draglines, and scoops.

Shells constitute a small (but sometimes important) local source of calcium carbonate. Ground or burned oyster shells are used extensively as a liming material in parts of Delaware, Maryland, and New Jersey. Neutralizing values as high as 95 percent have been reported for some shell piles. Dust from the manufacture of buttons also has been used in a few places.

Refuse-lime includes a number of byproducts of the chemical industry, purification sludges from agricultural processing plants, and lime used in water-softening processes. Some of them contain both calcium carbonate and hydroxide. Others are referred to as precipitated or finely divided calcium carbonate. Most of these sources of discard lime, including those of sugar beet and water-softening plants, paper mills, and other industries generally have such a high content of water that they are hard to handle and spread.

Piles of refuse-lime from gasworks and acetylene plants may contain sulfur impurities and traces of gas, which may injure seeds. On exposure to air, however, the sulfides are oxidized quickly to sulfates, and the gases escape in a short time.

Refuse-lime, which has a high neutralizing value, often can be obtained at little or no cost. Labor and transportation costs and the size of the pile may determine the extent of their use in a locality.

The oxide form of lime is sold under such names as burned lime, quicklime, caustic lime, lump lime, and unslaked lime. It is produced commercially by heating any form of calcium or magnesium carbonate, driving off the carbon dioxide, and leaving oxides of calcium and magnesium. This material is caustic and disagreeable to handle. Its neutralizing value is 150 to 185, according to the impurities in it, its percentage of magnesium, and the completeness of burning.

Burned lime that comes in contact with moisture becomes slaked. In this process, the oxides of calcium and magnesium take on water and become hydroxides. Other commercial names for it are hydrated lime, slaked lime, caustic lime, and agricultural hydrate. Like the oxide, it is usually marketed in bags as a fine powder. Hydrated lime has the objectionable characteristics of burned lime, but it reacts quickly with acid soils.

Calcium hydroxide has a theoretical neutralizing value of 135, but that of the commercial product usually is 125 to 145, because it contains some carbonates and possibly oxides, depending on the degree of slaking.

Only a small amount of oxide and hydrate is used for liming purposes, but their advantage over ground limestone is the rapid rate of reaction with soil. The National Lime Association estimated in 1948 that about 1.2 percent of the total tonnage of all lime used came from this source.

Wood ashes have some use as a liming material, although they are relatively scarce. Their rather low neutralizing value ranges from 30 to 70 percent, expressed as calcium carbonate. The ash of hardwoods, such as maple, elm, oak, and beech, contains about one-third more calcium than the ash of softwoods. Freshly burned wood ashes contain calcium mainly as the oxide, but, on exposure to moisture, they are largely in the carbonate form by the time they are applied to soil.

Coal ash has little or no liming value and benefits ascribed to it are probably a result of improvement in the physical condition of soil.

Blast furnace and basic slags (by-products in the smelting of iron ore)
SOIL REACTION AND LIMING

and calcium silicate slag (from rock phosphate reduction furnaces) are satisfactory liming materials. At furnace heats, silica in iron ore and rock phosphate combines with calcium of the limestone or phosphate rock to form calcium silicate. This compound breaks down in acid soils to liberate calcium and metasilicic acid. Slag must be finely ground if it is to be effective. A typical basic slag contains 6 to 10 percent of calcium silicate, 40 to 50 percent of calcium oxide, 4 to 5 percent of magnesium oxide, and 5 to 20 percent of phosphoric oxide.

Experiments comparing slag and limestone in several Southeastern States indicate that slag contains enough boron to raise yields of several legumes more than limestone does.

THE QUALITY of a liming material is determined by purity and fineness. The rate of reaction with soil is essentially a function of the size of the lime particle and (to a lesser extent) the type of liming material and the degree of mixing with the soil. The finer the lime, the greater is its specific surface, and consequently the more rapid are the changes brought about by liming.

Burned lime, agricultural hydrate, and refuse-lime normally have a very fine texture and require no grinding. Particles of limestone and basic slag larger than those passing an 8-mesh sieve, however, dissolve very slowly even in strongly acid soils. Almost all States require that at least 80 percent or more of the material pass through a sieve that has 8 to 10 meshes to the square inch.

When limestone rock is crushed, ground, and coarse-screened, a material ranging from coarse particles to dust is produced. The relative proportion of coarse, medium, and fine particles determines its reactivity. Because the cost of grinding increases as fineness increases, however, it is not practical to grind all limestone to pass, say, a 50- or 60-mesh sieve—a fineness that would make almost all of it available within 3 years.

Many farmers have used agricultural meal, a common grade of limestone of medium fineness, of which 95 percent or more will pass an 8-mesh sieve and 25 percent or more will pass a 100-mesh sieve. In some types of farming, such as truck gardening, a fine lime is desired, especially for rapid reaction. Pulverized limestone, 65 percent or more of which passes a 100-mesh sieve, or hydrated lime may then be used.

Dolomitic limestone, which is less soluble than calcitic stone, commonly is ground fine for agricultural use.

Some agronomists believe that much of the agricultural limestone has been too coarse to produce the desired effects of liming, and that finer grinding is practical, because grinding is only a small part of the total cost of limestone delivered and spread.

In the Agricultural Conservation Program, the specifications of 16 States for standard ground limestone require that 25 percent or more of the material must pass a 100-mesh sieve. Five States have set a requirement of 30 to 50 percent of the total to pass a 60-
mesh sieve. Fineness of lime is emphasized in Northeastern States and Ohio and North Carolina, which gave assistance payments for lime in 1953 only when 40 percent of a limestone passed a 100-mesh sieve. Eleven States had no specifications regarding material finer than 10- or 20-mesh.

Agronomists of several Midwestern States have concluded that limestone ground to pass an 8-mesh sieve is adequate, since it contains considerable fine dust for quick neutralization of soil acidity. Because the distribution of limestone particles in soil is usually far from perfect, they have felt that any advantages of grinding finer than 8-mesh are not great enough to justify the higher price of the finer material.

The main aim of liming is to mix lime uniformly with the surface layer of soil. Surface applications, followed by plowing or disking and harrowing, accomplish that aim most easily. Tillage is necessary because calcium from lime applied to the surface moves downward very slowly in most soils. Surface liming of pastures also is a recommended practice, especially before renovation. A few reports have indicated that finely divided limestone applied in the row for crops like soybeans on acid soils increase yields markedly.

Technicians generally recommend that limestone be applied at least 6 months to a year before seeding legumes, especially when a field is limed for the first time because young alfalfa and clover need abundant calcium.

Lime may be applied at any time of the year on land plowed for cultivated crops in the spring where small grains and legumes are to follow; on land plowed for winter grain with a legume to follow; on land following harvest of cultivated crops; on sod ground before plowing for a cultivated crop; and on permanent pasture.

Lime is spread by trucks, two-wheeled lime or fertilizer distributors, and endgate lime spreaders. Most of the lime is spread by custom operators. Trucks equipped with V-shaped beds and centrifugal spreaders at the rear are used for hauling and spreading.

Lime can be applied in that way on plowed ground, but many truckers prefer to spread lime on sod, pasture, or cultivated crops after the harvest. Applications in late summer or fall are usually most convenient, because then the roads and fields are generally in a good condition.

In places where hydrated or burned lime is applied or when lime is shipped in by railroad car and when weather conditions prevent the use of heavy trucks, a two-wheeled, box-type spreader is commonly used. Some equipment, designed for lime or fertilizer, can haul more than 1,000 pounds and apply lime at the rate of 2 tons an acre.

Grain drills equipped with fertilizer compartments can be used to apply small amounts of lime at seeding time or in a separate operation, but they cannot be used for materials high in moisture, such as marl.

The endgate spreader attached to the end of a wagon box has been used to spread lime. Special attachments of this type are available for manure spreaders. Many dairy farmers mix limestone with manure before loading or dump lime on the top or bottom of a load of manure. Up to 200 pounds of limestone to a ton of manure may be spread without a special operation.

More than 400 million tons of limestone were used in 35 States in the period 1930–1954. The ten North Central States used about 3.5 times as much lime as any other region. Second highest in the use of lime were the East Central States. Next were the Northeastern States and the Gulf States.

The Northeast, East Central, and North Central States increased their limestone consumption 5, 6.5, and 12 times, respectively, from 1930–1935 to 1950–1954, but a 58-fold increase occurred then in the Gulf States.

The total tonnage used in Illinois in 25 years was almost double the amount used in any other State. Indiana, Ohio, Iowa, Wisconsin, and Missouri
each used 30 million to 40 million tons in 1930–1945. Pennsylvania and Kentucky each used about 21 million tons of limestone.

Assistance payments for liming as a soil conserving practice, together with an improvement in farm income and an intensive educational program, boosted limestone consumption from less than 4 million tons in 1935 to more than 30 million tons in 1947. Between 1940 and 1949, 80 to 95 percent of the limestone used in most States was bought under an assistance program. In 1954 less than 67 percent of lime was purchased through the Agricultural Conservation Program.

The amount used has dropped since 1947; less than 20 million tons of agricultural limestone were used in 1954.

Our agricultural soils still need large amounts of limestone. Agronomists of land-grant colleges and universities in 37 States estimated in 1956 that 161 million acres would be improved by liming. They estimated that the lime required for those soils in 1956 on a corrective basis (rather than an annual basis) would be more than 332 million tons, or an average application per acre of slightly more than 2 tons. If the total figure is compared with the 407 million tons of limestone used in 1930–1954, the actual lime requirement for maximum crop production is about 80 percent of the amount used then.

Data compiled by the National Agricultural Limestone Institute indicated that the limestone tonnage for the Nation in 1954 was only 23.5 percent of the annual needs. On that basis, about 80 million tons of lime would be required annually.

Legal regulations control the quality of limestone that is sold. A number of States include restrictions on liming materials in their fertilizer laws. Others group lime with fertilizer, regulating both as agricultural minerals.

About half the States have laws that apply to specific agricultural liming materials and generally list the materials that qualify as lime. Almost all States require the licensing of manufacturers, dealers, and importers, and the labeling of their products.

Bagged or packaged materials generally must carry the name, brand or trademark, the name and address of the manufacturer, the minimum neutralizing value in terms of calcium carbonate or calcium oxide, and the percentages of the total material that will pass certain screens.

The purchaser of lot or bulk material usually receives an invoice or waybill bearing such guarantees.

Few States have set up legal limitations as to the purity and fineness of liming materials. Delaware, Maryland, Rhode Island, and Wisconsin have laws establishing required degrees of purity. Alabama, North Carolina, Ohio, Rhode Island, Virginia, and Wisconsin have set up legal standards of fineness for one or more grades of liming material.

The specifications for lime set by the Agricultural Conservation Program have brought considerable uniformity to standards of fineness and neutralizing value. In order to qualify in this program, lime must pass the specifications set up by State committees of the Agricultural Conservation Program. For instance, 15 States have set a minimum neutralizing value of 80 percent for standard ground limestone, 8 States have legalized a minimum level of 85 percent, and 12 States require a neutralizing value of at least 89.2 percent calcium carbonate equivalent.

In States where marl and refuse-lime from sugar beet factories, paper mills, and water-softening establishments are sold, a minimum of 70 percent on a dry basis is commonly accepted. Since these materials are often sold on a volume basis, the ACP specifications of several States require that a cubic yard contain 800 pounds of calcium carbonate. Carbide refuse-lime must have a neutralizing value of 85 percent.

The minimum neutralizing value for blast furnace slag is quite variable in six or seven States where it is distributed. One State accepts slag as low as 70 percent calcium carbonate equivalent.