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INSULATING MATERIAL

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This invention relates generally to thermal and acoustical insulating materials. More particularly the invention relates to such materials which are especially useful as roof board insulation and as acoustical tile for room ceilings.

Insulating products have been made for some years using various inert type aggregates, fibrous materials and binders. For example exfoliated vermiculite and expanded perlite have been used, separately, for some years as aggregates in insulating boards and the like. Vermiculite is a micaceous material which expands or exfoliates upon being heated to form a light weight insulating aggregate. Perlite is a generic term for certain volcanic glasses which upon being heated to controlled temperatures also expand to form light weight particles having good thermal and sound insulating properties.

It has been known that both expanded perlite and exfoliated vermiculite possess special efficacy when used in conjunction with fibers and certain binders for making light weight insulating boards or the like. Certain of such products, which have been found to be extremely useful for roof board applications as well as acoustical ceiling tiles, have included a large proportion of either vermiculite or perlite aggregate, as low a proportion of fibers as is commensurate with the strength contributing characteristics of this ingredient, and enough binder to hold the aggregate and fibers firmly together in a dimensionally stable board composition.

Such products have traditionally been formed using the so-called "wet process." This involves preparation of a water slurry of the board ingredients including defibrillation of the fibrous material, uniform suspension of the solids throughout the slurry by agitation, dewatering of the slurry by passing it over a drainage screen or the like to produce a felted wet board, light compression of the wet board to consolidate and impart uniform thickness to it, and finally drying of the board. Both exfoliated vermiculite and expanded perlite recommended themselves highly for use in boards of this type. Board forming slurries containing either of these materials tend to de-water quickly thus rendering the slurry advantageously free filtering in nature. In addition, as noted, both materials are light in weight and possess good thermal and sound insulating efficiency.

There thus results a conventional three component insulating board, i.e., containing a single aggregate, loose fibers and a binder, comprising an intertangled mass of loose fibrillae which entrap and hold the particles of aggregate in spaced apart relation throughotu the board.

Such conventional insulating products have, however, not been completely satisfactory for the various applications in which they have been used because of the need for an improvement in both their thermal and sound insulating efficiency. When expanded perlite has been used as the aggregate the resulting board has possessed poor resistance to heat transfer by radiation. When exfoliated vermiculite has been employed the boards have been overly dense thus contributing to an undesirably high coefficient of thermal conductivity. In either instance all of the fibers have been present in a loose or individualized condition in which state they cannot contribute in any substantial way to the insulating properties of the board.

It is a primary object of the present invention to improve upon these prior compositions by providing insulating materials having all of their advantages, e.g., light weight, good strength, ease of forming in the "wet process," and, additionally, possessing materially better thermal as well as acoustical insulating qualities as well as better fire resistance.

An ancillary object of this invention is to provide a general purpose insulating board having especially good heat and sound insulating characteristics while yet combining optimally low weight per unit volume with adequately high flexural strength. Another object is to provide such a board which is easy to handle and yet becomes a permanent part of the building structure or the like in which it is used.

A further object of the invention is to provide a light weight insulating material which possesses at one and the same time a high noise reduction coefficient and a low coefficient of thermal conductivity.

We have discovered that the insulating value of the known, conventional products described above, which include as essential ingredients thereof an aggregate, defibrillated fibers and a binder, may be materially enhanced by adding thereto a substantial but not dominant proportion of specially shaped mineral wool particles. These particles are prepared by forming mineral wool fibers into tiny bullets or kernels which are about the size and shape of rice kernels. The size, shape and character of the balls or kernals used in this invention is to be sharply distinguished from that of conventional so-called pelletized, nodulated or granulated mineral wool in which the fibers are loosely interwoven into large size mats or pieces measuring from a minimum of about one-half inch across to as much as two inches or more.

In the forming of the insulating materials which constitute the present invention the kernels or bullets of mineral wool are uniformly dispersed throughout the board making slurry, and consequently throughout the final board. The net result is that small units of high efficiency thermal and sound insulating material are evenly spread throughout the board. Importantly, these kernels are completely separated one from another by the other board ingredients to thus form isolated insulating units which are discontinuous throughout the board as contrasted with the continuous mats of fibers present in boards containing conventional so-called pelletized mineral wool. Spacing of the tiny mineral wool balls used in the present invention one from another prevents their sticking or webbing together in large conglomerates which would be detrimental to the flexural strength, heat transfer by convection, and other properties of the board.

Importantly, the proportion of mineral wool kernels present in the final board should vary between about 25 and about 50% by weight of the final board composition. Use of less than about 25% by weight of kernels fails to accomplish the aims of the invention while use of more than about 50% often unduly weakens the board for practical applications.

Not only have the specific ingredients of our insulating compositions been selected and combined together with care, so too have the proportions of ingredients been chosen to give optimum results. Our invention thus also comprises use of the following ranges of proportions, by total weight of the final dry insulating composition, for each of the ingredients:

	Percent
Expanded perlite	20–40
Exfoliated vermiculite	10–25
Fibers	10–25
Kernelized mineral wool	25–50
Binder	5–15

As indicated the expanded perlite aggregate used in our compositions should comprise 20–40% by weight of the total composition. The expanded perlite particles facilitate de-watering of the wet board slurry and, being hollow in nature, contribute voids to the interior of the final board thereby resisting transfer of heat by convection and conduction. The exfoliated vermiculite, present in the board in the amount of 10–25% by weight, contributes to the compressive and tensile strength of the board as well as to its indentation resistance. It is additionally a relatively highly reflective material and thus enhances resistance of the board to heat transfer by radiation.

In practicing the invention the exfoliated vermiculite particles should have an apparent or bulk density of about 6 pounds per cubic foot or so, and the expanded perlite particles should have a bulk density of approximately 3–5 p.c.f., although departures from these ranges may be made in appropriate circumstances. Mesh sizes of the exfoliated vermiculite aggregate of from about 20 mesh to about 4 mesh, and of the expanded perlite aggregate of from about 100 mesh to about 12 mesh, are preferably used although for some purposes other sizes may be used just as well.

Kernelizing of the mineral wool to be used in our insulating compositions may be accomplished by starting with either loose mineral wool fibers or with the commercial product known as nodulated or granulated mineral wool. The latter comprises small groups of loose fibers from which some of the heavy, dense impurity particles known as "shot" have been removed. In any event one or the other of these starting materials, both commercially available, may be added to a large volume of water and agitated under such conditions that the mineral wool becomes kernelized to the size of rice kernels and is thus ready for use in the instant invention. For example, 25 pounds of nodulated mineral wool fibers may be added to a 50 gallon drum (22 inches inside diameter) holding a large volume of water, say 27 gallons. Mixing may be accomplished using a slow moving (cf. 400 r.p.m.) propeller type stirrer which just barely clears the inside periphery of the container (e.g., about two inches clearance). After mixing for about 5 to 10 minutes the mineral wool fibers are found to have formed the small, compact, self-contained particles having a bullet or kernel shape which are useful in the present invention.

One of the by-product advantages of so kernelizing the mineral wool before incorporation in the insulating materials of the present invention is that much more of the "shot" impurities are removed from the loose fibers during the kernelizing process thus further enhancing the light weight and high insulating efficiency of the resulting kernels.

Fibrous substances useful herein, all of which are used in their defibrillated or individualized condition, include various organic fibers, e.g., newsprint pulp, kraft paper pulp, bagasse and others, as well as certain inorganic fibers such as asbestos. As noted, the fibrous material is so dispersed in the board making slurry that the individual fibers are separated one from another, thus assuring their presence in the final board composition as a mass of intertangled fibers which surround the aggregate particles as well as the mineral wool kernels. Long or short fibers may be used equally well, or a mixture of fibers of different lengths may be employed successfully if this is desired.

It will be understood that the mineral wool kernels described above are not included within the so-described fibrous substances. As explained, the mineral wool bullets are tightly packed bundles of fibers which are themselves held in spaced apart relationship by the defibrillated fibrous substances. The mineral wool kernels function mainly as isolated insulating units in contrast to the function of the individualized fibers in forming a supporting and holding matrix for the other components of the board.

Examples of binding materials useful in practicing the invention, used either alone or in combination, are bentonite clay, starch and asphalt added either as a solid or in the form of an emulsion. Other materials having like properties may also be employed.

As indicated, an amount of binder should be used equal to about 5 to 15% by weight of the final board composition. Bentonite clay is of course incombustible and its use enhances the fire resistance of the board. It also functions as a water repellent inasmuch as it swells in the presence of water and thereby tends to fill surrounding board voids so that further take-up of water by the board becomes more difficult. If starch is employed as binder it is possible to use minimum quantities of fibrous materials to thereby lighten the board and often improve its fire resistance. Asphalt is of course an inexpensive, easy to use binding material which also functions to waterproof the board. Often combinations of these materials give especially good results. For example, combining the use of bentonite clay with starch improves the fire resistance of the board while yet assuring high binding strength. The use of bentonite clay in conjunction with asphalt improves the fire resistance and moisture resistance of the board.

Several embodiments of the invention have been described in some detail below in order to enable those skilled in this field to apprehend fully the principles and to produce such units using only the ordinary skills of their specialty. No inference should be drawn, however, from the detailed character of the description that the invention is limited in its employment to any such details of composition or procedure. On the contrary, a wide variety of embodiments is possible, as will readily occur to those skilled in this field, and the intention is to cover all alternatives, substitutions and equivalents falling within the spirit and scope of the invention as expressed in the appended claims.

The following examples are given to illustrate the insulating composition but as noted should not be construed as limiting the invention to the exact materials and conditions shown therein.

Example I

A board was made in the following manner. Newsprint in such proportion as to constitute 15% by weight of the final dry board was added to water to make a dilute paper pulp slurry. An appropriate amount of binder, in this instance starch solution in the amount of 10% solids by weight of the final board, was added to the slurry.

Next, previously kernelized mineral wood particles were added to the slurry in such quantity that these particles would constitute 25% by weight of the final dry board composition.

Exfoliated vermiculite and expanded perlite particules were then added to the slurry. The proportions of these aggregates were selected such that the final dry board composition would contain 25% by weight exfoliated vermiculite and 25% by weight expanded perlite.

The slurry was agitated thoroughly so that the various ingredients were intimately mixed together. While the slurry was kept suspended by agitation it was uniformly fed to a square suction mold including a horizontal screen or sieve. Upon de-watering of the slurry in the suction mold a felted wet board was formed on the mold screen. The wet board was pressed to 1" thickness, removed from the mold, and dried.

The resulting board had a K-factor (coefficient of thermal conductivity in B.t.u. per hour per square foot per degree F. per inch thickness determined at a means temperature of 75° F.) of 0.40, a noise reduction coefficient (NRC) of 0.72, a density of 10.6 pounds per cubic foot, and a flexural strength of 70.0 pounds per square inch. In addition the board had excellent fire resistant qualities as determined by the standard Columbia curve fire resistance test in which a flame up to 1800° F. is applied to the surface of the board for a period of forty-five minutes.

Example II

A mixture similar to that of Example I was made except that the proportions by weight and ingredients of the final dry board were as follows: 15% exfoliated vermiculite, 40% expanded perlite, 10% newsprint fibers, 25% kernelized mineral wool and 10% binder (5% starch and 5% bentonite clay). The mixture was suspended by agitation as before and poured into the same suction mold as that used in Example I. The resulting felted wet board was consolidated by pressing, removed from the mold, dried and subjected to various physical tests as before.

It was found that the board had a K-factor of 0.39, an NRC of 0.74, a density of 10.9 p.c.f., and a flexural strength of 70.6 p.s.i.

Example III

A mixture similar to that of Example I was made except that the proportions and ingredients of the final dry board were as follow: 15% exfoliated vermiculite, 30% expanded perlite, 15% newsprint fibers, 30% kernelized mineral wool and 10% starch binder. A water slurry of ingredients was made up generally as before. Once again the mixture was suspended by agitation and poured into a suction mold. As before the resulting board was consolidated by pressing, dried and tested.

The final board had a K-factor of 0.38, an NRC of 0.715, a density of 11.3 p.c.f. and a flexural strength of 61.8 p.s.i.

Example IV

Once more a mixture similar to that of Example I was made up except that the proportions and ingredients of the final dry board were the following: 15% exfoliated vermiculite, 35% expanded perlite, 10% newsprint fibers, 30% kernelized mineral wool and 10% binder (5% starch, 5% bentonite clay). A water slurry of the ingredients was made up and the mixture processed as before to form a board.

The final dry board was found to possess a K-factor of 0.40, and an NRC of 0.70, a density of 11.3 p.c.f. and a flexural strength of 71.5 p.s.i.

Example V

The procedure of Example I was followed once again except that the proportions and ingredients of the final dry board were as follows: 15% exfoliated vermiculite, 25% expanded perlite, 10% newsprint fibers, 40% kernelized mineral wool and 10% binder (5% each of starch and bentonite clay). As before a water slurry of the ingredients was made up, the slurry was de-watered to form a wet felted board and the wet board was dried and tested.

The final dry board had a K-factor of 0.40, an NRC of 0.72, a density of 12.6 p.c.f., and a flexural strength of 71.3 p.s.i.

It is understood of course that the noise reduction coefficient (NRC) measures the sound absorbing efficiency of a given material and is determined by a standard test. This test consists of measuring the reverberation room sound absorption efficiency of the tile at a series of fixed sound frequencies, cf. at 250, 500, 1,000 and 2,000 cycles per second. The arithmetic average of the reverberation room sound absorption coefficients at each frequency becomes the overall noise reduction coefficient. The average noise reduction coefficient of conventional acoustical tile often varies in the range of .40 to .60. It is understood that the higher NRC value designates the better sound insulator.

Likewise the K-factor is a standard measure of the thermal efficiency of insulating materials. Its importance as a determinant of the quality of insulating materials is well known. The lower the K-factor, the better the heat insulating qualities. The insulating board industry recognizes boards having a K-factor of about 0.40 or below as being of special efficacy for various insulation end uses, including the insulating of roof decks.

As will be seen from the examples, the insulating materials of the present invention are possessed of extremely good sound insulating qualities, i.e., an NRC of 0.70 or over. This compares with noise reduction coefficients of only about 0.40–0.60 for most prior acoustical insulating materials. In addition to their noise reducing qualities the instant boards have also been found to be highly resistant to sound transmission.

At the same time the insulating materials disclosed herein have very low coefficients of thermal conductivity, i.e., about 0.40, thus rendering them especially useful for insulating commercial buildings and the like. The high strength and low density characteristics of the instant insulating materials further enhance their value as all purpose insulation boards, i.e., they are easy to carry and handle, simple to install and yet are strong enough to retain their shape and even to support modest loads. The improved fire resistance of the instant boards enhances their use either as roofing insulation or as acoustical tile.

Aside from the essential ingredients of the insulating materials of the present invention, other useful ingredients of the finished boards can also be included. For example, termite repellants, materials which will prevent the formation and growth of algae, sizing materials in cases where the binder component of the boards does not impart to them sufficient resistance to water absorption, surface smoothing ingredients such as diatomaceous earth, etc., may be added in those instances where desirable for a particular end usage of the board.

Any of the various available board forming machines may be employed for forming the boards described herein on a commercial scale, including Fourdrinier machines, rotary vacuum filters or cylinder type board machines, all of which operate continuously, and suction mold type equipment.

It will be understood that the term "mineral wool" as used herein includes those materials known in the art as rock wool, slag wool, glass wool, glass fibers, and the like.

We claim as our invention:

1. A light weight insulating composition consisting essentially of expanded perlite particles comprising about 20–40% by weight of the composition, exfoliated vermiculite particles comprising about 10–25% by weight of the composition, fibers comprising about 10–25% by weight of the composition, mineral wool present as particles having the approximate size and shape of rice kernels and comprising about 25–50% by weight of the composition, and a binder comprising about 5–15% by weight of the composition.

2. A light weight insulating composition consisting essentially of expanded perlite particles having a bulk density of approximately 3–5 p.c.f. and being from about 100 mesh to about 12 mesh in size, said perlite particles comprising about 20–40% by weight of the composition, exfoliated vermiculite particles having a bulk density of approximately 6 p.c.f. and being from about 20 mesh to about 4 mesh in size, said vermiculite particles comprising about 10–25% by weight of the composition, fibers comprising about 10–25% by weight of the composition, mineral wool present as particles having the approximate size and shape of rice kernels and comprising about 25–50% by weight of the composition, and

a binder comprising about 5–15% by weight of the composition.

3. A light weight insulating composition consisting essentially of an intertangled mass of fibers, expanded perlite and exfoliated vermiculite particles dispersed in said mass of fibers, mineral wool particles having the approximate size and shape of rice kernels uniformly dispersed throughout said mass of fibers, said mineral wool particles comprising about 25–50% by weight of the composition, and a binder for holding said particles and said fibers together in dimensionally stable condition.

4. The insulating composition defined by claim **3** in which the expanded perlite particles comprise about 20–40% by weight of the composition, the exfoliated vermiculite particles comprise about 10–25% by weight of the composition, the fibers comprise about 10–25% by weight of the composition, the mineral wool particles comprise about 25–50% by weight of the composition,

and the binder comprises about 5–15% by weight of the composition.

5. The insulating composition defined by claim **3** in which the binder is selected from the group consisting of starch, asphalt, bentonite clay, and combinations thereof.

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