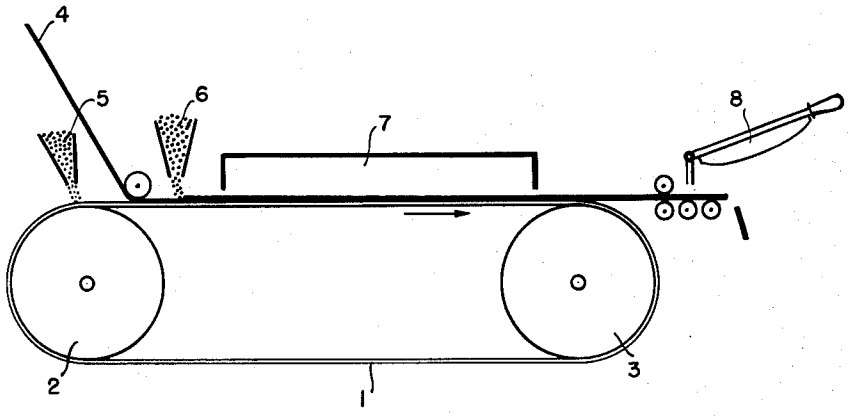
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PRODUCTION OF FIREPROOFING SHEETS

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PRODUCTION OF FIREPROOFING SHEETS

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This invention relates to the production of fireproofing sheets and more particularly to fireproofing sheets having increased thermal insulating efficiency when exposed to high temperatures.

The protection of buildings, vehicles, containers and other constructions against the action of heat and fire is a considerable safety problem.

It is known to achieve such protection by providing the objects to be protected with a coating of a non-combustible and flameproofing material, as for example a solution of an alkali silicate or alkali phosphate and the like.

Fire-retardent and heat-insulating coatings are applied, for example, by brushing or spraying on to the surfaces to be protected. Naturally, the effect of these coatings is better the thicker the layer applied. For the production of thick layers, for example thicknesses of more than 0.3 mm., a single coating is usually not sufficient and a plurality of coatings must be applied consecutively. Application of a coating of adequate thickness is consequently attended by considerable expenditure of labor; on the other hand, layers which are too thick have a strong tendency to scale off and break off after drying. In many cases, as for example in steel constructions, protection by means of a coating is not sufficient because the applied layer may not adhere sufficiently firmly to the metallic support. On the other hand, with materials which exhibit a certain absorptivity, as for example wood, there is the risk that the coating composition containing waterglass will penetrate into the material and considerably damage it by its strongly alkaline action. While it is true that an article treated in this way is flammable only with difficulty, the thermal insulation of these coatings is only slight so that they cannot prevent penetration of heat to the material to be protected so that, upon prolonged exposure, the material either ignites or is otherwise damaged.

In the event of fire, these coatings in part swell and, upon prolonged exposure to heat, finally lose their closed structure, for example by cracking, scaling off and the like, so that the objects to be protected become exposed to the action of the flame. In order to obviate this disadvantage, it has been proposed to add non-combustible finely divided fillers, as for example shale flour, to the alkali silicate solutions serving as the coating agents. The tendency of the coatings to form cracks under the action of heat is decreased by this measure, but not completely avoided. Nor are the said other disadvantages of the coating obviated thereby.

In order to decrease crack formation under the action of heat it is also known to provide the material to be protected with two protective coatings differing considerably from each other in their physical characteristics, a priming coating and a covering coating, the priming coating having a lower melting point and a smaller coefficient of expansion than the covering layer. The priming coating may consist of kieselguhr and glass powder, while the covering coating may consist of ground porcelain and stoneware. Waterglass solution serves as the binding agent in both cases. This certainly diminishes the tendency for the formation of cracks upon the occurrence of a fire, but the above-mentioned disadvantages of coatings cannot be obviated by this process.

For fireproofing combustible materials, as for example wood, paper, cardboard, textiles and the like, it is also known to impregnate them with a mixture of waterglass and finely ground mica. It is also known to use a cardboard soaked with a mixture of waterglass and caustic alkali for the production of articles where stability to heat is required, as for example fireproof walls, packing materials and the like. While materials thus treated do not burn easily, it is not possible to prevent burning upon prolonged exposure to a flame. Moreover their insulating efficiency and mechanical stability are poor.

It is further known to combine articles to be protected against the action of a flame with thermally insulating materials, especially porous materials, in order to retard the spread of the fire. Various methods for the production of such heat-insulating and fireproof constructional articles are known which contain as binding agents alkali silicates in anhydrous form. Such highly porous insulating materials may be prepared by pressing fibrous organic raw materials, for example wood wool, straw, reeds and the like, together with pulverulent materials, as for example asbestos flour, sand, kaolin slip and the like in sheet metal molds perforated on all sides, with waterglass as the binding agent, and then drying at elevated temperatures. It is also known to grind natural asbestos finely, mix it with waterglass and again to grind fine the mixture thus prepared. This powder is then mixed with fibrous asbestos and dilute waterglass, the resultant composition pressed into molds, dried and fired.

It is furthermore known to produce heat and sound insulating boards by processing asbestos fibers, glass staple fibers or slag wool into felts and impregnating these felts with such an amount of a solution of a heat-resistant binder that the finished felt contains about 100% to 200% by weight of liquid. In a special step the felt is then provided in the wet state with pocket-like depressions by profiling and finally dried. The dried material is to contain at least 60 to 95% of fibers, i.e., have a fiber content of at least 150% based on binder.

Contrasted with these porous insulating panels which consist essentially of difficultly combustible materials and fibrous substances and which contain waterglass only as binder, materials are also known which have a foamy structure and the main component of which is silicate formed from waterglass.

Such materials may be prepared by evaporating to dryness an alkali silicate solution to which may have been added fibrous or other reinforcing materials, such as asbestos, to such an extent that it contains 10 to 35% of water, comminuting the resultant product, if desired adding powdered alkali borate to increase stability to water, and then heating the mixture in molds at temperatures of 200° to 500° C. To increase the porosity of such a building material it has been proposed to carry out the heating in an atmosphere containing carbon dioxide. A solution of sodium chloride may be added to the waterglass solution for the same purpose, the swelling and loosening of the mass being promoted by the bursting of the crystals of sodium chloride upon heating.

An essential disadvantage of these heatproofing compositions is that they have very little mechanical stability and take up a great deal of space in relation to the construction on account of their porous structure and the desired effect. Moreover, the production of such heat-proofiing compositions is expensive and time-consuming by reason of the numerous working operations and the high temperatures necessary.

It is an object of the present invention to provide

flameproofing sheets which upon exposure to high temperatures, for example to fire, assume increased thermal insulating properties and which, as compared with known sheets of a similar type, exhibit considerable advantages.

In accordance with our invention, these objects and advantages are achieved in a technically very simple manner by embedding synthetic fibers of inorganic nature in a layer of an alkali silicate solution and then solidifying the layer to a dense plate by withdrawal of water.

The process may be carried out by placing the fibers in a trough in the form of individual fibers, skeins or in the form of non-woven or woven fabrics or knitted fabrics and covering them with an alkali silicate solution or by introducing them into the alkali silicate solution, the mass then being exposed to elevated temperatures until a compact sheet has formed. The water is preferably removed at a temperature below the boiling point of the water contained in the alkali silicate solutions. A simple experiment shows that the water content in a flameproofiing sheet at which the sheet has sufficient stability may be up to about 80% based on the content of anhydrous alkali silicate. In order to facilitate release of the finished sheet from the trough, it is convenient to brushcoat or line the trough with water-repellent substances. Suitable substances include silicones, polyethylene, polytetrafluoroethylene, rubber and the like. Glass fibers are especially suitable for the process. Quartz fibers, mineral wool and steel wool may also be used.

It is also possible to prepare sheets of the said kind continuously by effecting the embedding of the fibers and the subsequent removal of water on a moving endless belt. The endless sheeting leaving the drying zone may be cut with a cutting means to any desired size depending on the application.

The endless belt serving as a support on which the plates are produced conveniently has a water-repellent surface, as for example a rubber surface, in order to prevent undesirable adherence of the solidified alkali silicate after drying. The same purpose may also be achieved by a sheet moving with the band. The surface of the endless belt may be plane or it may have a special shape by which any desired profiled surface may be imparted to the plates. For example corrugated sheets may be prepared in this way.

The alkali silicate solution may be supplied under and/or above the fibrous material, for example by spraying.

The layers may be dried for example by means of infrared radiators, electrically heated radiators, alone or in combination with hot air blown in countercurrent to the fabric belt supporting the layers.

Apparatus for carrying out the process according to the invention is shown diagrammatically by way of example in the accompanying drawing.

An endless belt **1** passes over rollers **2** and **3** and roller **2** can be rotated by a suitable drive (not shown). An aqueous alkali silicate solution, if desired mixed with a wetting agent, is continuously supplied through jets **5** and **6** and a fabric web **4** is embedded therein. The embedded web **4** then passes through a drying zone **7**. The sheeting leaving the drying zone may be cut to any desired size with cutting means **8**.

The flamephoofing sheets obtained in this way are surprisingly very flexible and have remarkable mechanical stability although they contain water in not inconsiderable amounts. By reason of these properties it is possible without much difficulty to apply the flameproofing sheets to articles to be protected by mechanical methods or by bonding, or to arrange them inside the article. They have the property of expanding to a stable and very finely pored foamed layer when exposed at least to such a high temperature that the water contained therein boils, such as is the case for example in the event of fire. Contrasted with sheets which have been prepared without adding fibers, these expanded sheets have

no tendency to crack by reason of the reinforcement by the fiber framework, have a coherent structure and offer a very high resistance to the penetration and passage of heat energy. Above all, naked flames cannot penetrate because the expanded sheets are crack-free. Depending on the nature of the heating, the sheets may be expanded to up to about 15 times their original thickness. The thermal insulation effect of the fireproofing sheets according to this invention is quite considerably superior to the effect of the above-mentioned coatings or porous building materials.

It is advantageous from a technical point of view that the new flameproofing sheets can be installed in unexpanded form. Contrasted with expanded insulating materials, as for example the above-mentioned porous asbestos plates, profiled felt and panels of foamed material, the new sheets require very little space.

The alkali metal silicates, especially sodium and potassium silicates, used according to this invention may be applied as aqueous solutions of any concentration. We understand solutions also to include colloidal solutions, e.g. dispersions. It is however advantageous to use concentrated but flowable aqueous solutions, which in the case of sodium silicate solutions contain about 50 to 70% by weight of dry substance with reference to the solution (corresponding to 37° to 50° Baumé).

It is advantageous to add about 10 to 25% by weight of fibrous material with reference to the anhydrous alkali silicate used in order to obtain a mechanically strong and effective product that is easy to process. It is also possible, however, to add up to 60% by weight of fibers. On the other hand, clearly improved mechanical properties and improved expansibility are observed as compared with a waterglass plate without fiber addition, when the flame-proofing sheets according to this invention contain a proportion of fiber or fabric of only 0.5% with reference to the anhydrous silicate.

The alkali silicate solution for treating the fibrous material is preferably mixed with a wetting agent. This ensures that wetting will be rapid and satisfactory. The usual wetting agents, as for example alkali salts of sulfonic acids, may be used.

By adding coloring materials it is possible to obtain colored flameproofing sheets, which by reason of their color and incombustibility are eminently suitable for decorations in department stores or display windows and also as incombustible scenery in film studios and theaters.

Colored flameproofing sheets of this kind may be subdivided, for example by cutting, into segments of any desired shape in a simple way and these can then be assembled by known methods, such as nailing or sticking, on a support to give the desired picture composition.

The expandable flameproofing sheets according to the invention may be protected by coatings, for example plastic layers, from evaporation of the water serving as blowing agent, or from water, chemicals and the like.

To achieve a firmly adherent finish or a firmly adherent coating by laminating with plastic sheets and the like, it is convenient to introduce into the alkali silicate sheets containing the fibers or fabric, before or after consolidation, materials, preferably oblong or angular, which partly project from the surface.

Suitable materials for this purpose include granular sand, fragments of gypsum, and pegs of metal or other material. The size of these articles depends on the thickness of the alkali silicate layer and on the thickness and type of coating to be applied to the flameproofing sheet. The part of the article projecting from the flameproofing sheet should be of such length that a satisfactory connection is ensured.

The articles may be introduced into the alkali silicate layer while it is still liquid or into the sheets after they have been solidified. In the latter case they are forced under pressure, if desired at an elevated temperature, partly into the alkali silicate sheets. It is convenient to

introduce the articles into a layer which has been solidified to a certain extent by partial extraction of water but is still plastic. The articles then do not sink entirely into the layer, but they are anchored sufficiently firmly in the finished sheets.

To increase the resistance to creep stress and to improve the mechanical attachment to the objects to be protected, the fireproofing sheets may be combined with metal wire netting before or after solidification. The netting may be directly embedded with the fiber additions in the alkali silicate solutions, which are then solidified by withdrawal of water. It is also possible to remove water to such an extent from the alkali silicate solutions already containing fibers that a plastic or solid sheet is formed into which the netting is pressed, if necessary at an elevated temperature.

By reason of their high mechanical stability, such reinforced flameproofing sheets are outstandingly suitable for example as fire walls and the like.

If two or more flameproofing sheets prepared according to this invention are bonded, for example with alkali silicate solution, multilayer panels are obtained which are considerably more rigid than single layer sheets. In order to obtain a protective coating against very intense heat action, it is recommendable to add heat-resistant fillers, as for example quartz flour, talc, titanium dioxide or aluminum oxide to the alkali silicate solution used for bonding flameproofing sheets.

Multilayer panels thus prepared are dried so that a residue of water remains in the adhesive layer. Such multilayer panels are for example eminently suitable for protecting metal plates against welding flames. The heat generated by welding flames can be so strongly reduced that a multiple of the time otherwise required to weld the metal plates is necessary.

Various building elements, as for example wall coverings, linings, insulating panels, door, partitions and the like may be made from this new material alone or in combination with other materials. For example sheets of the new flameproofing material may be applied to other materials, such as prestressed concrete, wood, plastics and the like, either by mechanical means, such as nailing or riveting, or also by the known methods of laminating and bonding.

Even readily flammable or readily fusible materials are thereby protected from the action of heat. The flameproofing materials according to the invention may for example be used in fireproof doors, safes, ships and constructional parts of ships, exhibition halls, blocks of flats and offices, building constructions of all kinds, vehicles, aircraft, packing containers, as for example barrels, tanks and numerous other objects, which hinder or arrest the progress of a fire once started and offer great resistance to high temperatures.

For example shaped articles of polystyrene foam or polyester cast resins can also be protected excellently from igniting even upon prolonged exposure to heat by providing them with coatings of flameproofing sheets according to the invention, for example by bonding. Inorganic or organic adhesives may be used.

The invention is illustrated by, but not limited to, the following examples, in which parts are by weight.

EXAMPLE 1

140 parts of an aqueous solution of sodium waterglass with a dry content of about 50% (determined after drying for several hours at about 80° C. and corresponding to about 37° Baumé) is poured into a trough and then a non-woven fiber fabric weighing 25 parts is laid therein. As soon as the glass fiber fabric has been completely wetted, the mixture is consolidated by withdrawing water for about 14 hours at a temperature of 50° C. A dense elastic flameproofing sheet is obtained weighing about 100 parts in which the glass fiber fabric is embedded.

The drying period can be considerably shortened by drying at 140° C.

Wetting is considerably accelerated if 0.5% of a wetting agent, for example the product sold under the trade name Tensaktol A, is added to the sodium waterglass.

EXAMPLE 2

A non-woven fiber fabric weighing 25 parts is laid as described in Example 1 in 225 parts of an aqueous solution of potassium waterglass with 32% dry content (corresponding to 29° Baumé), determined as in Example 1, and the layer solidified by withdrawing water. A compact and elastic flameproofing sheet is obtained.

EXAMPLE 3

A non-woven glass fiber fabric weighing 17 parts is laid as described in Example 1 in 140 parts of an aqueous solution of sodium waterglass with a dry content of about 50% determined as in Example 1, and then solidified as described in Example 1. A compact and elastic flameproofing sheet is obtained.

EXAMPLE 4

360 parts of an aqueous solution of sodium waterglass with a dry content, determined as in Example 1, of about 50% to which 0.5% of a wetting agent has been added is poured into a trough as described in Example 1 and then a non-woven glass fiber fabric weighing 12 parts is laid therein. After drying at 50° C. about 200 parts of a flameproofing plate with about 6% of fiber component is obtained. Unlike a waterglass sheet without fibers, such a plate is resistant to bending stress.

If a sheet prepared in this way and having a thickness of 1.2 mm. is heated with a gas burner, an expanded sheet is formed having a thickness of about 15 mm.

EXAMPLE 5

300 parts of waterglass with a dry content of about 50% is poured in a trough lined with polyethylene film as described in Example 1 and 0.75 part of glass fibers is embedded therein so that the fibers cross each other and are distributed as uniformly as possible over the whole layer.

By drying, a sheet is obtained which, unlike a waterglass sheet free from fibers, may be subjected to bending stress and which expands uniformly when heated.

EXAMPLE 6

Flameproofing sheets prepared according to Examples 1 to 3 are coated with a highly viscous dispersion of a copolymer of methyl acrylate and butyl acrylate and the coating, serving as adhesive layer, allowed to dry before a film of rigid polyvinyl chloride or a copolymer of vinylidene chloride is laminated therewith.

The flameproofing sheets thus acquire a waterproofness which is adequate for practical requirements.

EXAMPLE 7

By the process described in Example 6, the flameproofing sheet provided with an adhesive layer is made waterproof by brushing on an emulsion of a copolymer on the basis of vinylidene chloride.

EXAMPLE 8

Two or more of the flameproofing sheets prepared according to Example 1 are bonded by brushing the first sheet on one side with an about 53% waterglass solution and sticking on the second sheet. After drying the waterglass layer, another sheet may be stuck on if desired. This process may be repeated ad lib.

To solidfy the waterglass coatings, the multilayer panel must then be dried. In this way building panels are obtained. Even with only two layers, the building panel is very rigid and can only be bent with difficulty.

EXAMPLE 9

A 1.2 mm. flameproofing sheet prepared according to Example 1 is heated on both sides between metal plates with gas burners. The water therein boils and there is soon formed a foamed layer about 8 mm. in thickness which has lost about 15 to 20% of its weight by loss of water as compared with the original plate. The foamed flameproofing plate becomes more resistant to water at the same time. The bulk density lies at about 200 g./l.

EXAMPLE 10

A flameproofing sheet prepared according to Example 1 is nailed onto a chip board and provides protection against ignition even upon prolonged exposure to the strong heat of a Bunsen flame. After ten minutes, the chip board shows merely a slowly spreading carbonization.

The flameproofing sheet does not crack when the nails are driven in and even at the nailed places does not know cracks in the foamed layer which forms under the action of heat. The flameproofing sheet may be provided with a plaster finish or a wallpaper prior to nailing.

EXAMPLE 11

A 20 mm. sheet of expanded polystyrene is bonded with a fireproofing sheet prepared according to Examples 1 to 3 using highly viscous waterglass. After drying, the fire resistance is tested by exposing the panel in an inclined position to a gas flame with the fireproofing sheet underneath, the point of the flame being deflected at the fireproofing sheet. A foamed layer forms under the action of the heat and this insulates so well that the expanded polystyrene arranged behind the same does not begin to melt at the hottest place until after 2 to 4 minutes. Furthermore, the fused polystyrene does not ignite even after several hours heat exposure because the flame cannot penetrate the foamed layer at any point.

If a sheet of expanded polystyrene is coated only with waterglass, the flame penetrates under the same test conditions after only a few minutes and sets light to the polystyrene foam behind the same because the protective layer ruptures.

EXAMPLE 12

A flameproofing sheet prepared according to Examples 1 to 3 is bonded with a glass fiber reinforced polyester sheet by means of a highly viscous dispersion adhesive of a copolymer of methyl acrylate and butyl acrylate. If the two-layer panel thus prepared is exposed to a flame as described in Example 11, the adhesive layer is destroyed with brown discoloration. The glass fiber reinforced polyester sheet is however protected from destruction by the good heat insulation of the foamed layer formed under the action of the heat. Even after exposure to heat for several hours, the polyester sheet does not ignite.

EXAMPLE 13

Into a metal trough measuring 135 x 45 x 5 cm. which is lined with a sheet of polypropylene, 100 grams of glass fibers with a mean staple length of 3 to 5 cm. and 4000 grams of an aqueous solution of sodium waterglass with a dry content of 50% are introduced and dried for an hour at a temperature of about 110° C. About 2 kilograms of sand with a mean grain size of 2 to 3 mm. is uniformly scattered on the still plastic plate thus formed and pressed in gently. Then the plate is dried for another 2 hours at about 110° C. A layer of plaster, about 2 cm. thick and prepared from 3 parts of fine sand, 1 part of cement and about 1 part of water, is applied to the plate which is now solid. The plaster layer adheres well to the alkali silicate sheet after setting.

EXAMPLE 14

A wire netting weighing 165 grams, with a wire thickness of 0.5 mm. and a distance between the wires of 2.5 cm. is laid in a trough of rigid polyvinyl chloride having a surface area of 1.4 meters by 1.0 meter. 250 grams of glass fibers with a staple length of 3 to 5 cm. is uniformly shaken onto the netting. 5000 grams of an aqueous sodium waterglass solution with a dry content of about 50% is added with the aid of a perforated flat dish and the mixture dried overnight at 70° C.; a sheet about 1.5 mm. in thickness and with an average water content of 20% is obtained.

The sheet thus prepared is nailed onto a square wooden frame having an edge length of 40 cm., the side provided with the wire netting being directed toward the frame. The frame is then mounted in a support in such a way that the side provided with the flameproofing sheet is directed downward. After laying a 5 kilogram weight on the sheet, the sheet is intensely heated from below with two Bunsen burners for 30 minutes. The foamed layer formed shows small cracks but only after cooling, the coherence of the sheet remaining intact. The foamed layer does not break even at the nailed points. In an analogous test carried out with a flameproofing layer without embedded wire netting, the weight breaks through.

Similar results are achieved by using only 110 grams of glass fibers or by using a non-woven fiber fabric weighing 800 grams instead of the glass fibers.

EXAMPLE 15

120 grams of glass fibers is uniformly spread in the mold described in Example 14. Then the wire netting described in Example 14 is laid in and finally another 130 grams of glass fibers added. Then 5000 grams of an aqueous sodium waterglass solution with a dry content of 50% is carefully sprayed in. The whole is dried for 16 hours at 70° C. A sheet with a high resistance to creep stress is obtained.

EXAMPLE 16

A wire mesh netting with a distance between wires of 2.5 cm. and a weight of 40 grams is laid between two square fireproofing sheets 1.2 mm. in thickness with an edge length of 30 cm. which contain 30% of non-woven glass fiber fabric. A paper coated with polyethylene is applied to the outer surfaces of the fireproofing sheets, the paper side being in contact with the surface of the flameproofing layers. These layers are pressed in a press between some sheets of soft filter paper for 30 minutes at 100° C. and a pressure of 200 atmospheres.

The flameproofing panel thus obtained is extremely resistant to pressure and bending and resistant to the action of water or moisture.

EXAMPLE 17

140 grams of staple glass silk with a staple length of 3 to 5 cm. is uniformly scattered and thereupon 130 grams of mineral wool is laid in the mold described in Example 14. Then 7000 grams of sodium waterglass (37° Baumé) is added.

The mineral wool is pressed well into the waterglass layer with the aid of a rubber roller and the whole is then dried for about 15 hours at 70° C. The fireproofing sheet 3 to 4 mm. in thickness thus prepared having a water content to about 40% with reference to the weight of the solid plate, gives a foamed layer on heating to 400° C. which is especially pressure-resistant and fine-pored.

We claim:

1. Fireproofing sheets having increased thermal insulating efficiency when exposed to high temperatures which consist essentially of alkali metal silicate, synthetic inorganic fibers embedded in said alkali metal silicate, and water, the amount of said inorganic fibers being from 0.5 to 60% by weight and the amount of water being from 31.1 to 80.0% by weight, said percentages being with reference to anhydrous alkali metal silicate.

2. Fireproofing sheets according to claim 1, wherein the synthetic inorganic fibers are glass fibers.

3. Fireproofing sheets according to claim 1, wherein said sheets are protected by a film of a synthetic polymer or copolymer applied to said sheets.

4. Fireproofing sheets according to claim 1, wherein said sheets contain wire netting.

5. A process for the production of fireproofing sheets having increased thermal insulating efficiency when exposed to the action of high temperatures which comprises: covering uniformly scattered synthetic inorganic fibers with an aqueous solution of an alkali metal silicate, said silicate being a member selected from the group consisting of sodium silicate and potassium silicate, said fibers being used in an amount of 0.5 to 60% by weight with reference to the amount of anhydrous alkali metal silicate contained in the solution, and consolidating the layer to a compact sheet by removal of water at temperatures between 50 and 140° C. in such an amount that the water content of the consolidated layer is from 31.1 to 80.0% by weight with reference to the amount of anhydrous alkali metal silicate contained in the layer.

6. A process according to claim 5, wherein the synthetic inorganic fibers are glass fibers.

7. A process according to claim 6, wherein wire netting is incorporated into the alkali metal silicate solution.

8. A process for the production of fireproofing sheets having increased thermal insulating efficiency when exposed to the action of high temperatures which comprises: introducing synthetic inorganic fibers into a layer of an aqueous alkali metal silicate solution in an amount of 0.5 to 60% by weight with reference to the amount of anhydrous alkali metal silicate contained in said aqueous solution and consolidating the layer to a compact sheet by removal of water at temperatures between 50 and 140° C. in such an amount that the water content of the consolidated layer is from 31.1 to 80.0% by weight with reference to the amount of anhydrous alkali metal silicate contained in the layer.

9. A process according to claim 8, wherein the synthetic inorganic fibers are glass fibers.

10. A process according to claim 9, wherein wire netting is incorporated into the alkali metal silicate solution.

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