

A THERMAL INSULATION MATERIAL AND A FIRE AND HEAT PROTECTION SYSTEM COMPRISING THEREOF

Field of Invention

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The invention relates to the field of fire and heat protection systems. Particularly, the invention relates to a thermal insulation material suitable for use in a fire and heat protection system. The thermal insulation material is malleable and capable of self-hardening and forming an internal vapor barrier when exposed to fire or high temperatures.

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Background of Invention

Ductwork is a network of ducts used in the heating, ventilation, and air conditioning (HVAC) system to deliver and remove hot and cold air in many large residential and commercial buildings. Often, the ducts are insulated by protective coverings such as flexible wraps. Ductwork insulation offers numerous benefits. It improves energy efficiency by limiting heat loss or gain, reducing leakage and providing vapor barrier against moisture. Accordingly, ductwork insulation reduces operational demand on the equipment and extends lifespan of the equipment, thereby enhancing performance of the HVAC system. Ductwork insulation also mitigates duct condensation, which prevents ducts from freezing in cold weather. Besides, ductwork insulation minimizes operational noise of the HVAC system and noise generated by fluid flow within the duct system. Furthermore, duct insulating wraps prevent entry of dust and allergens into the duct system, thereby preventing circulation of dust and allergens in the indoor space and improving indoor air quality.

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In addition to the abovementioned benefits, ductwork insulation improves fire safety of the buildings. The HVAC duct system can inadvertently cause fires to spread quickly within a building, causing hot gases and toxic smoke to spread around the building. Fire-resistant duct wrap is a form of passive fire protection. Insulating the ductwork with fire-resistant wrap delays or prevents the spread of fire and smoke through the duct system, offering crucial evacuation time in emergencies.

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A number of patented technologies has disclosed various forms of fire rated duct wrap. A United States Patent No. US8178177B2 disclosed a non-self-supporting, flexible fire-protecting article fitted around the duct and secured to the duct in a single layer. The fire-protecting article comprises a non-combustible fibrous material and an intumescent material. The non-combustible fibrous material is mineral fibers, fiberglass, ceramic fibers, and blends thereof whereas the intumescent material is graphite, sodium silicate, vermiculite, and blends thereof. The fire-protecting article is secured to the duct in a configuration wherein the article has room to expand outwardly to its expanded reactive thickness. Particularly, the intumescent material in the fire-protecting article expands in response to an intense heat, enabling the fire-protecting article to expand in response to a heated condition of the duct. The expanded fire-protecting article creates a larger volume of space in which the fire-protecting article may trap heat, increasing its thermal insulation capability. With an increased thermal insulation capability, the expanded fire-protecting article may help slow the passage of heat from one side of the article to the other.

A self-hardening flexible insulation material with resistance to elevated temperatures ($>300\text{ }^{\circ}\text{C}$) for pipe or tank is disclosed in European Patent No. EP2420532B1. The insulation material comprises at least one layer of an expanded, vulcanized organic polymer-based blend having organic polymers with potential to form additional bonds and/or crosslinking at elevated temperatures and fillers that form stable bonds and/or supporting crosslinking reactions at temperatures above $280\text{ }^{\circ}\text{C}$. The organic polymers may be thermoplasts, thermoplastic elastomers, elastomers, thermosets or any mixtures thereof whereas the filler may be clay. The insulation material exhibits a controlled self-hardening effect that leads to a stable rigid foam insulation in a rather short time at elevated, but not extreme temperatures. The insulation material may further comprise a layer of temperature invariant materials as a protective layer between a hot surface and the polymer blend layer. The temperature invariant materials may be fibres of glass, ceramics, minerals, carbon, aramide, imide, etc. The material may further comprise additional layers on top of the polymer blend layer to protect it from weathering, UV or mechanical impact. The insulation material may further comprise additional parts that form a pre-insulated system with the layers.

The present invention provides a fire rated insulation material for pipes and ductwork that is capable of self-intumescent and self-hardening at elevated temperatures to protect the pipes and ducts from fire damage and to slow down if not prevent the spread of fire. Particularly, the fire rated insulation material is capable of forming an internal vapor barrier.

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Summary of Invention

An object of the invention is to provide a thermal insulation material suitable for use in the fire and heat protection system for pipes and ducts. Preferably, the thermal insulation material is malleable under non-fire conditions. When exposed to elevated temperatures, the thermal insulation material is triggered to form into a hardened clay structure having a carbonized outer layer and an internal gel-like mass, in which water molecules are trapped, forming an internal vapor barrier in the clay structure. The internal vapor barrier insulates heat and fire, thereby preventing the spread of flames and heat.

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The carbonized outer layer helps to prevent the water molecules from escaping the clay structure, thereby maintaining the internal vapor barrier. It also inhibits, suppresses, or delays the production of flames and prevents the spread of fire.

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Another object of the invention is to provide a fire and heat protection system for pipes and ducts comprising the aforementioned thermal insulation material. Particularly, the system comprises a malleable wrapping material having a core layer made of the thermal insulation material. The malleable wrapping material can be wrapped around pipes and ducts of various shapes and structures under non-fire conditions. In the event of fire, the core layer of the malleable wrapping material is triggered to self-harden and form a fire and heat insulation structure having an internal vapor barrier surrounding the pipes and ducts.

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At least one of the preceding objects is met, in whole or in part, in which the embodiment of the present invention describes a thermal insulation material, the thermal insulation material having a composition comprising a clay mineral, a base, a non-halogenated flame retardant, a non-alkaline borate, and a starch, wherein the thermal insulation material is malleable and is capable of self-hardening and forming an internal vapor barrier when

exposed to fire or a temperature exceeding 100 °C, thereby preventing the transfer of fire or heat.

5 In a preferred embodiment of the invention, the clay mineral is either montmorillonite or kaolinite.

In a preferred embodiment of the invention, the base is selected from aluminium hydride hydroxide, magnesium hydroxide, huntite, hydromagnesite, various hydrates, metal phosphates, hydrated calcium, boron compounds, and borates.

10 In a preferred embodiment of the invention, the non-halogenated flame retardant is selected from red phosphorus, organic phosphates and phosphonates, melamine phosphate, melamine derivatives, melanine cyanurate, expandable graphite, talc, and ammonium polyphosphate.

15 In a preferred embodiment of the invention, the non-alkaline borate is selected from boric acid, zinc borate, borax and calcium borate.

20 In a preferred embodiment of the invention, the starch is selected from cornstarch, tapioca, arrowroot, wheat starch, rice starch, potato starch, sweet potato starch, sago, green bean starch, and artificial starch.

25 In a preferred embodiment of the invention, the clay mineral is present at about 1% to 20% by total weight of the composition, the base is present at about 20% to 50% by total weight of the composition, the non-halogenated flame retardant is present at about 15% to 40% by total weight of the composition, the non-alkaline borate is present at about 1% to 15% by total weight of the composition, and the starch is present at about 20% to 40% by total weight of the composition.

30 In a preferred embodiment of the invention, the thermal insulation material further comprises a silica. Preferably, the silica is selected from quartz, tridymite, cristobalite,

coesite, stishovite, lechatelierite, and chalcedony. Preferably, the silica is present at about 1% to 15% by total weight of the composition.

In a preferred embodiment of the invention, the thermal insulation material further comprises hollow microspheres. Such microspheres may be carbon microspheres, (and if combined with agents such as ammonium polyphosphate (APP), they can create an intumescent flame retardant), glass microspheres, (as their high silica content and internal voids give them heat resistance and they can act as a light weight filler that provides a good flame-retardant effect), silica or bio-based (microspheres e.g. K-carrageen or nucleotide-based compounds to create more environmentally friendly flame retardants) or cenospheres (which are hollow, lightweight microspheres that are naturally fire-resistant due to their high silica and alumina content and they possess a high melting point). However, preferably, the hollow microspheres are either glass microspheres (based on phosphate glasses, boron or silicate glasses, or laminated glass waste) or ceramic microspheres formed from or including the aforesaid glass microspheres. In such form, the hollow glass microsphere or ceramic microsphere is based on sodium borosilicate glass. Preferably, the diameter of hollow microspheres employed are in the range of 10um to 100um. More preferably still, the hollow microspheres are present in the thermal insulation coating in the range of about 1% to 15% by total weight of the composition. For the avoidance of doubt silica may also be present in this embodiment independently of the microspheres.

In a preferred embodiment of the invention, the thermal insulation material further comprises a polymer resin.

Preferably, the polymer resin is a thermoplastic resin selected from polyethylene, polyvinyl chloride, polystyrene, polypropylene, polycarbonate, polytetrafluoroethylene, polyether, ether ketone, polyoxymethylene, polyamide, acrylic, phenol formaldehyde resin, acrylonitrile-butadiene-styrene, acrylonitrile styrene acrylate, polyvinyl acetate, ethylene-vinyl acetate, vinyl acetate-vinyl chloride, polyvinyl alcohol, and polybutylene terephthalate.

Preferably, the polymer resin is a thermosetting resin selected from polyester, vinyl

ester, vinyl acetate, epoxy, phenolic, polyurethane, and bismaleimide.

In a preferred embodiment of the invention, the polymer resin is present at about 1% to 10% by total weight of the composition.

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In one embodiment of the present invention further describes a fire and heat protection system comprising the abovementioned thermal insulation material. The system comprises a malleable wrapping material comprising a core comprising a core layer made of the thermal insulation material sandwiched between a first ceramic fiber layer and a second ceramic fiber layer; a fire-retardant shrink wrap enwrapping the core; and an aluminium foil enwrapping the core enwrapped in the shrink-wrap. The malleable wrapping material is configured to wrap around an object and capable of forming a hardened core layer having an internal vapor barrier therewithin when exposed to fire or a temperature exceeding 100 °C, thereby protecting the object from the fire or overheating.

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In another embodiment of the present invention further describes a fire and heat protection system comprising the abovementioned thermal insulation material. The system comprises a malleable wrapping material comprising a core comprising a core layer made of the thermal insulation material sandwiched between a first ceramic fiber layer and a second ceramic fiber layer; a fire-retardant shrink-wrap enwrapping both the core, and the core layer, and an aluminium foil enwrapping the core enwrapped in the shrink wrap.

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The malleable wrapping material is configured to wrap around an object and capable of forming a hardened core layer having an internal vapor barrier therewithin when exposed to fire or a temperature exceeding 100 °C, thereby protecting the object from the fire or overheating.

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In a preferred embodiment of the invention, the aluminium foil is reinforced with fiberglass.

In a preferred embodiment of the invention, the object is a duct selected from a grease duct, a chemical exhaust duct, a heating, ventilation, and air conditioning (HVAC) duct, and a life safety duct.

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In a preferred embodiment of the invention, the object is a pipe of a pipe system or pipe penetration system.

5 In a preferred embodiment of the invention, the thermal insulation material of the system is reinforced with hollow microspheres of the type specified hereinabove.

Brief Description of Drawings

10 For the purpose of facilitating an understanding of the invention, there are illustrated in the accompanying drawings the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

15 Figure 1 is a sectional view of the malleable wrapping material (110) according to a preferred embodiment of the invention.

Figure 2 is a sectional view of the malleable wrapping material (110) according to another preferred embodiment of the invention.

20 Figure 3 is an enlarged sectional view of the malleable wrapping material (110) as shown in Figure 2.

25 Figure 4 shows a first exemplary embodiment of the fire and heat protection system (100), in which the malleable wrapping material (110) is applied on a duct system.

Figure 5 shows a second exemplary embodiment of the fire and heat protection system (100), in which the malleable wrapping material (110) is applied on a pipe penetration system.

30 Figure 6 shows a third exemplary embodiment of the fire and heat protection system (100), in which the malleable wrapping material (110) is applied on a pipe

system.

Detailed Description of Invention

5 Hereinafter, the invention shall be described according to the preferred embodiments of the present invention and by referring to the accompanying description and drawings. However, it is to be understood that limiting the description to the preferred embodiments of the invention is merely to facilitate discussion of the present invention and it is envisioned that those skilled in the art may devise various modifications without departing from the scope
10 of the appended claim.

The present invention describes a thermal insulation material (1), particularly a fire-resistant insulation material. The thermal insulation material (1) is suitable for use in a fire and heat protection system (100) for pipes and ductwork. Preferably, the thermal insulation
15 material (1) has a clay composition. More preferably, the composition of the thermal insulation material (1) comprises a clay mineral, a base, a non-halogenated flame retardant, a non-alkaline borate, and a starch. The thermal insulation material (1) may be obtained by mixing these ingredients until a homogeneous mixture is obtained. The resulting homogeneous mixture can be further processed into compact sheet-like structures for easier
20 handling and application.

Advantageously, the thermal insulation material disclosed herein is malleable and flexible when the ambient temperature or its surface temperature is below 100 °C. When the ambient temperature or its surface temperature exceeds 100 °C, the thermal insulation
25 material is triggered to self-harden, forming a fireproof barrier that prevents the transfer of fire or heat. The terms “elevated temperatures” and “high temperatures” as used herein refer to ambient temperature or surface temperature exceeding 100 °C. Particularly, the hardened thermal insulation material has a rigid outer surface with an internal vapor barrier that insulates heat and prevents oxygen from reaching the flame. Preferably, the thermal
30 insulation material (1) of the invention is capable of insulating temperatures up to 1200 °C, in accordance to testing standard based on BS 476 and EN 1366 etc., listed in Code of Practice for Fire Precautions in Buildings 2023 Singapore.

Pursuant to the preferred embodiment of the invention, the clay mineral in the thermal insulation material (1) acts as the filler and provides a structural base for the fire and heat protection system (100) comprising the thermal insulation material (1) to stabilise during high temperatures. The clay mineral has a catalytic effect and chemically interacts with the base.

Preferably, the clay mineral is montmorillonite. Montmorillonite is preferred due to its high melting point. It can absorb high amount of heat without decomposition and form into clay instead of brittle glass at high temperature. Furthermore, montmorillonite swells upon hydration, giving rise to gel-like masses. Montmorillonite forms into bentonite clay at high temperature. Preferably, the clay mineral is present at about 1% to 20% by total weight of the thermal insulation material composition.

Alternatively, the clay mineral is kaolinite. This material has the advantage that when it is heated, it undergoes a series of irreversible phase transformations driven by the loss of water, the specific products depend upon on the temperature reached during calcination. However, above 1400 °C, the phase transformation provides increased structural strength and heat resistance.

In the preferred embodiment of the invention, the base in the thermal insulation material (1) enhances fire retardant properties of the thermal insulation material and the fire and heat protection system (100) comprising thereof. Particularly, the base absorbs heat and releases water molecules during high temperatures. Preferably, the base is selected from aluminium hydride hydroxide, magnesium hydroxide, huntite, hydromagnesite, various hydrates, metal phosphates, hydrated calcium, boron compounds, and borates. The preferred bases comprise ionically bonded hydroxide ions or water molecules. The ionic bonding starts to break down at elevated temperatures, releasing water molecules from the bases. The water molecules released form a fireproof heat barrier. Preferably, the base is present at about 20% to 50% by total weight of the thermal insulation material composition.

In accordance with the preferred embodiment of the invention, a non-halogenated flame retardant is used in the thermal insulation material (1). Non-halogenated flame retardant is

non-toxic and does not release hazardous gases during combustion. Particularly, non-halogenated flame retardant promotes carbonization of the surface of the thermal insulation material (1) at elevated temperatures to form a protective carbon layer. The formation of the carbon layer improves the insulation property of the thermal insulation material (1).
5 Preferably, the carbon layer traps the water released by the base within the hardened thermal insulation material.

The carbon layer also acts as radical scavenger that prevents the escape of free radicals from the thermal insulation material. Furthermore, the carbon layer blocks entry of oxygen,
10 thereby inhibiting, suppressing, or delaying the production of flames and preventing the spread of fire. Preferably, the non-halogenated flame retardant is selected from red phosphorus, organic phosphates and phosphonates, melamine phosphate, melamine derivatives, melamine cyanurate, expandable graphite, talc, and ammonium polyphosphate. Preferably, the non-halogenated flame retardant is present at about 15% to 40% by total
15 weight of the thermal insulation material composition.

In one preferred embodiment of the invention, the non-alkaline borate in the thermal insulation material (1) acts as a non-toxic fire retardant that suppresses fire and smouldering. It synergises with the other ingredients in the thermal insulation material (1) for better
20 thermal and mechanical properties. For example, the non-alkaline borate aids in the carbonization of the surface of the thermal insulation material at high temperature. Preferably, the non-alkaline borate is boric acid, zinc borate, borax and calcium borate. Non-alkaline borate releases water when exposed to elevated temperature, thereby extinguishing fire and terminating flameless combustion. Non-alkaline borate also helps to
25 form a protective char on the surface of the thermal insulation material at elevated temperature. Preferably, the non-alkaline borate is present at about 1% to 15% by total weight of the thermal insulation material composition.

In one preferred embodiment of the invention, starch is used in the thermal insulation
30 material (1) as it is a naturally occurring polysaccharide that exhibits charring properties. It helps with the carbonization of the surface of the thermal insulation material (1) when exposed to elevated temperatures. Furthermore, it acts as a bonding agent that bind the

ingredients of the thermal insulation material together. Moreover, it is a poor conductor of heat, retarding heat transfer. Preferably, the starch is selected from cornstarch, tapioca, arrowroot, wheat starch, rice starch, potato starch, sweet potato starch, sago, green bean or mung bean starch, and artificial starch. Preferably, the starch is present at about 20% to 40% by total weight of the thermal insulation material composition.

According to one of the preferred embodiments of the invention, the ingredients of the thermal insulation material (1) work synergistically to produce a self-hardened thermal insulation material having an internal vapor barrier when exposed to temperatures above 100°C. The resulting self-hardened thermal insulation material exhibits improved fire-retardant properties, creating an effective flame and temperature barrier. Particularly, when the ambient temperature rises beyond 100°C, the clay mineral absorbs heat from the environment and forms into clay. The resulting clay is moldable owing to the presence of non-alkaline borate and starch in the composition. At the same time, the clay mineral or the clay transfers the absorbed heat to the base, causing water molecules to be released from the base. The released water molecules are quickly vaporized by the high heat. The vapor hydrates the clay mineral in the clay and causes the clay to swell and form a gel-like mass. The vapor molecules also absorb heat as latent heat. When water molecules are continuously released from the base, the vapor accumulates within the gel-like mass and forms a vapor barrier that insulates heat and flame. On the other hand, the non-halogenated flame, in conjunction with the non-alkaline borate and starch, promotes carbonization of the clay surface to form a rigid outer layer. The rigid outer layer prevents water molecules or vapor from escaping, hence maintaining the vapor barrier. Besides, the outer layer blocks entry of oxygen into the clay, thereby preventing fire from spreading through the insulation material. Advantageously, the self-hardened thermal insulation material having an internal vapor barrier does not trap all the absorbed heat which will cause its surface temperature to rise beyond 180 °C. The self-hardened thermal insulation material is capable of releasing some of the absorbed heat to a nearby object in order to reduce its surface temperature.

In another embodiment of the invention, the thermal insulation material (1) further comprises silica. Silica acts as a filler and enhances the thermal and mechanical properties of the thermal insulation material (1). Particularly, silica powder forms glass at high

temperatures. The presence of glass further increases the durability of the clay structure at high temperatures. Glass in the clay structure also facilitates the entrapment of water within the hardened thermal insulation material. Preferably, the silica is selected from quartz, tridymite, cristobalite, coesite, stishovite, lechatelierite, and chalcedony. Preferably, the silica is present at about 1% to 15% by total weight of the composition.

In yet another embodiment of the invention, the thermal insulation material (1) further comprises a polymer resin. Polymer resin act as a binder that further improves the malleability of the thermal insulation material (1) during non-fire scenarios. Preferably, the polymer resin is a thermoplastic resin or a thermosetting resin. The thermoplastic resin is selected from polyethylene (PE), polyvinyl chloride (PVC), polystyrene (PS), polypropylene (PP), polycarbonate (PC), polytetrafluoroethylene (PTFE), polyether, ether ketone, polyoxymethylene (POM), polyamide (PA) or nylon, acrylic (e.g. polymethyl methacrylate (PMMA)), phenol formaldehyde resin, acrylonitrile-butadiene-styrene (ABS), acrylonitrile styrene acrylate or acrylic styrene acrylonitrile (ASA), polyvinyl acetate, ethylene-vinyl acetate (EVA), vinyl acetate-vinyl chloride, polyvinyl alcohol (PVA), and polybutylene terephthalate (PBT). The thermosetting resin is selected from polyester, vinyl ester, vinyl acetate, epoxy, phenolic, polyurethane, and bismaleimide (BMI). Preferably, the polymer resin is present at about 1% to 10% by total weight of the composition.

The embodiment of the present invention further describes a fire and heat protection system (100) comprising the abovementioned thermal insulation material (1). Particularly, the fire and heat protection system (100) is suitable for use on pipe and ductwork systems. Preferably, the system comprises a malleable wrapping material (110) that is configured to wrap around an object (120) to be protected. The object (120) may be a duct selected from a group consisting of a grease duct, a chemical exhaust duct, a heating, ventilation, and air conditioning (HVAC) duct and a life safety duct such as stair pressurization duct, smoke duct, and exhaust duct. (see Figures 4, 5 and 6 for examples of such objects (120). Alternatively, the object (120) may be a pipe of a pipe system or pipe penetration system.

Preferably, the malleable wrapping material (110) is capable of forming a self-hardened core layer having an internal vapor barrier therewithin when exposed to fire or a

temperature exceeding 100 °C. Accordingly, a rigid protective layer is formed around the object (120), protecting the object (120) from the fire or overheating. Preferably, the malleable wrapping material (110) is capable of protecting the object (120) from high temperatures of 1200 °C or above.

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According to the preferred embodiment of the invention, the malleable wrapping material (110) is in the form of a flexible insulating blanket. Preferably, the malleable wrapping material (110) comprises a core (10) having the thermal insulation material (1) of the invention, an outer shrink wrap (20) and an outermost aluminium foil (30). As shown in Figure 1, it is preferred that the core (10) is completely encapsulated by the outer shrink wrap (20) whereas the outer shrink wrap (20) enwrapping the core (10) is completely encapsulated by the outermost aluminium foil (30). The malleable wrapping material (110) of the invention can be formed into continuous rolls or pre-cut sections. It should be understood that malleable wrapping materials (110) of various widths and lengths are within the scope of the invention.

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Preferably, as depicted in Figure 1, the core (10) comprises a core layer (11) made of the thermal insulation material (1) of the invention, a first ceramic fiber layer (12), and a second ceramic fiber layer (13). Preferably, the core layer (11) is sandwiched between the first ceramic fiber layer (12) and the second ceramic fiber layer (13). Optionally, the core (10) of the malleable wrapping material (110) comprises the core layer (11) as the inner layer and the first ceramic fiber layer (12) and/or the second ceramic fiber layer (13) as the outer layer(s), in which the malleable wrapping material (110) is configured to be wrapped around the object (120) with the core layer (11) facing the protected object (120) and the ceramic fiber layer(s) (12, 13) facing the surrounding environment. The core layer (11), the first ceramic fiber layer (12) and the second ceramic fiber layer (13) in the core (10) may have various thicknesses, provided the thickness of each layers is sufficient to provide the fire and heat protective characteristics.

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Preferably, the core layer (11) has a thickness that is adequate for the formation of an internal vapor barrier within the self-hardened thermal insulation material (1) upon exposure to high temperatures. The first ceramic fiber layer (12) and the second ceramic

fiber layer (13) are preferred to have similar or identical composition and thickness so as to provide balanced insulation effects on both sides of the malleable wrapping material (110). Alternatively, the first ceramic fiber layer (12) and the second ceramic fiber layer (13) may have different compositions and/or thickness to provide different insulating effects on both sides of the malleable wrapping material (110).

In the preferred embodiment of the invention, the first ceramic fiber layer (12) and the second ceramic fiber layer (13) contribute to the thermal resistance of the malleable wrapping material (110). The ceramic fiber layers (12, 13) prevent the core (10) of the malleable wrapping material (110) from melting due to the high internal temperatures caused by the heat insulation provided by the core layer (11). Preferably, the first ceramic fiber layer (12) and the second ceramic fiber layer (13) of the core (10) are in the form of ceramic fiber blankets. The ceramic fiber blankets are made of amorphous or crystalline synthetic mineral fibers with refractory properties. Particularly, these fibers are not flammable and can maintain their physical strength and structure at very high temperatures. The first ceramic fiber layer (12) and the second ceramic fiber layer (13) may comprise a mixture of alumina, silica, other metal oxides and/or nonoxide materials such as silicon carbide.

The fire retardant shrink wrap (20) will prevent any contamination of the thermal insulation material (1) by any additive that is present in the first ceramic fiber layer (12) and the second ceramic fiber layer (13). Accordingly, in the preferred embodiment of the invention, the outer shrink wrap (20) enwrapping the core (10) comprises a fire retardant to aid in preventing or slowing the spread of fire. Preferably, the fire retardant shrink wrap (20) also comprises a smoke suppressant to reduce the emission of smoke and harmful substances during fire. Furthermore, the fire retardant shrink wrap (20) is impermeable, rendering the malleable wrapping material (110) moisture resistant

In the preferred embodiment of the invention, the aluminium foil (30) enwrapping the core (10) enwrapped in the fire retardant shrink wrap (20) is reinforced with fiberglass. Fiberglass reinforced aluminium foil (30) enables the malleable wrapping material (110) to withstand corrosion from high humidity. It also provides the malleable wrapping material

(110) with strong resistance against impact and laceration.

5 The malleable wrapping material (110) of the invention was assessed in accordance with the Singapore Civil Defence Force (SCDF) Fire Code requirements. Particularly, the malleable wrapping material (110) was assessed by using the FSB/PSB/001, BS 476-20:1987, BS 476-24:1987, BS 476-4:1970, EN 1366-1:2014, EN 1366-8:2024, EN 1366-9:2024 and AS 1530.4:2014 test standards

10 The fire and heat protection system (100) may further comprise fixing means (130) including, but not limited to, stainless steel bandings, screws, cap and welded pins to secure the malleable wrapping material (110) around the object (120). Moreover, the fire and heat protection system (100) may further comprise an adhesive to bond the side edges of the malleable wrapping material (110) to itself when wrapping around the object (120).

15 Advantageously, the malleable wrapping material (110) in the fire and heat protection system (100) is flexible and can be easily shaped during non-fire scenarios, allowing it to be applicable to ducts and pipes of various shapes and structures. Figures 2 to 4 illustrate three exemplary embodiments where the malleable wrapping material (110) of the invention is applied on a duct system, a pipe system and a pipe penetration system, respectively. Besides, the malleable wrapping material (110) supports insulation, smoke
20 leakage control, integrity and stability of the duct and pipe systems at high temperatures owing to the presence of montmorillonite in the thermal insulation material (1) in the core layer (11). Particularly, when the ambient temperature or the surface temperature exceeds 100°C, the core layer (11) absorbs the heat, then the surface of the core layer (11) is triggered to self-harden and form an internal vapor barrier within the hardened outer layer.
25 The resulting hardened core layer serves as a fire and thermal barrier to the ducts or pipes wrapped in the malleable wrapping material (110). However, the hardened core layer does not trap all the absorbed heat within the system. It releases a fraction of the absorbed heat to the pipes and ducts wrapped in the malleable wrapping material (110), keeping its surface
30 temperature below 180 °C, thereby preventing components of the pipe and duct system that are in contact with the malleable wrapping material (110) from melting. Furthermore, the malleable wrapping material (110) is lightweight and easy to be installed. It is stable under

non-fire conditions and normal storage conditions.

According to another preferred embodiment of the invention, the malleable wrapping material (110) is in the form of a flexible insulating blanket. Preferably, the malleable wrapping material (110) comprises a core (10) having the thermal insulation material (1) of the invention, an outer shrink wrap (20) and an outermost aluminium foil (30). As shown in Figure 2 and in Figure 3, it is preferred that the core (10) is completely encapsulated by the outer shrink wrap (20) whereas the outer shrink wrap (20) enwrapping the core (10) is completely encapsulated by the outermost aluminium foil (30). However, the core layer (11) in this embodiment is also encapsulated by an 'inner' shrink wrap (20). As stated previously, the fire retardant shrink wrap (20) segregates materials and will prevent any contamination of the thermal insulation material (1) by any additive that is present in the first ceramic fiber layer (12) and the second ceramic fiber layer (13). The malleable wrapping material (110) of the invention can be formed into continuous rolls or pre-cut sections. It should be understood that malleable wrapping materials (110) of various widths and lengths are within the scope of the invention.

Claims

1. A thermal insulation material (1), the thermal insulation material (1) having a composition comprising a clay mineral, a base, a non-halogenated flame retardant, a non-alkaline borate, and a starch, wherein the thermal insulation material (1) is malleable and is capable of self-hardening and forming an internal vapor barrier when exposed to fire or a temperature exceeding 100 °C, thereby preventing the transfer of fire or heat.
2. The thermal insulation material (1) according to claim 1, wherein the clay mineral is either montmorillonite or kaolinite.
3. The thermal insulation material (1) according to claim 1 or 2, wherein the base is selected from aluminium hydride hydroxide, magnesium hydroxide, huntite, hydromagnesite, various hydrates, metal phosphates, hydrated calcium, boron compounds, and borates.
4. The thermal insulation material (1) according to any one of claims 1 to 3, wherein the non-halogenated flame retardant is selected from red phosphorus, organic phosphates and phosphonates, melamine phosphate, melamine derivatives, melanine cyanurate, expandable graphite, talc, and ammonium polyphosphate.
5. The thermal insulation material (1) according to any one of claims 1 to 4, wherein the non-alkaline borate is selected from boric acid, zinc borate, borax and calcium borate.
6. The thermal insulation material (1) according to any one of claims 1 to 5, wherein the starch is selected from cornstarch, tapioca, arrowroot, wheat starch, rice starch, potato starch, sweet potato starch, sago, green bean starch, and artificial starch.
7. The thermal insulation material (1) according to any one of claims 1 to 6, wherein the clay mineral is present at about 1% to 20% by total weight of the composition,

the base is present at about 20% to 50% by total weight of the composition, the non-halogenated flame retardant is present at about 15% to 40% by total weight of the composition, the non-alkaline borate is present at about 1% to 15% by total weight of the composition, and the starch is present at about 20% to 40% by total weight of the composition.

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8. The thermal insulation material (1) according to any one of claims 1 to 7, further comprising a silica.

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9. The thermal insulation material (1) according to claim 8, wherein the silica is selected from quartz, tridymite, cristobalite, coesite, stishovite, lechatelierite, and chalcedony.

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10. The thermal insulation material (1) according to claim 8 or 9, wherein the silica is present at about 1% to 15% by total weight of the composition.

11. The thermal insulation material (1) according to any one of claims 1 to 10, further comprising a polymer resin.

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12. The thermal insulation material (1) according to claim 11, wherein the polymer resin is a thermoplastic resin selected from polyethylene, polyvinyl chloride, polystyrene, polypropylene, polycarbonate, polytetrafluoroethylene, polyether, ether ketone, polyoxymethylene, polyamide, acrylic, phenol formaldehyde resin, acrylonitrile-butadiene-styrene, acrylonitrile styrene acrylate, polyvinyl acetate, ethylene-vinyl acetate, vinyl acetate-vinyl chloride, polyvinyl alcohol, and polybutylene terephthalate.

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13. The thermal insulation material (1) according to claim 11, wherein the polymer resin is a thermosetting resin selected from polyester, vinyl ester, vinyl acetate, epoxy, phenolic, polyurethane, and bismaleimide.

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14. The thermal insulation material (1) according to any one of claim 11 to 13, wherein

the polymer resin is present at about 1% to 10% by total weight of the composition.

15. The thermal insulation material according to any one of the preceding claims, further comprising hollow microspheres.
16. The thermal insulation material according to claim 15, wherein the hollow microspheres are either glass microspheres or ceramic microspheres formed from or including the aforesaid glass microspheres.
17. The thermal insulation material according to claim 16, wherein the hollow glass microsphere or ceramic microsphere is or is based on sodium borosilicate glass.
18. The thermal insulation material according to any one of claims 15 to 17, wherein the diameter of the hollow microspheres employed are in the range of 10um to 100um.
19. The thermal insulation material according to any one of claims 15 to 18, wherein the hollow microspheres are present in the thermal insulation coating at about 1% to 15% by total weight of the composition.
20. A fire and heat protection system (100) comprising a thermal insulation material (1) according to any one of claims 1 to 14, the system comprising:
a malleable wrapping material (110) comprising:
a core (10) comprising a core layer (11) made of the thermal insulation material (1) sandwiched between a first ceramic fiber layer (12) and a second ceramic fiber layer (13);
a fire retardant shrink wrap (20) enwrapping the core (10); and
an aluminium foil (30) enwrapping the core (10) enwrapped in the shrink wrap (20),
wherein the malleable wrapping material (110) is configured to wrap around an object (120) and capable of forming a hardened core layer having an internal vapor barrier therewithin when exposed to fire or a temperature exceeding 100 °C, thereby

protecting the object (120) from the fire or overheating.

21. The fire and heat protection system according to claim 15, wherein the aluminium foil (30) is reinforced with fiberglass.

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22. The fire and heat protection system according to claim 15 or 16, wherein the object (120) is a duct selected from a grease duct, a chemical exhaust duct, a heating, ventilation, and air conditioning duct, and a life safety duct.

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23. The fire and heat protection system according to claim 15 or 16, wherein the object (120) is a pipe of a pipe system or pipe penetration system.

24. The fire and heat protection system according to claim 15, wherein the thermal insulation material (1) is reinforced with hollow microspheres.

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25. The fire and heat protection system according to any one of claims 20 to 24, wherein the core layer (11) is enwrapped in the fire retardant shrink wrap (20).

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