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(54) Title: HIGH TEMPERATURE FLOW-LINE INSULATION

(57) Abstract: A pipe or flow-line suitable for operation at temperatures in excess of 170°C. The pipe or flow-line includes a corrosion resistant and an adhesive layer, a high temperature thermoplastic or rubber insulator, one or more layers of polyolefin and polyolefin foam, and an outer polyolefin or rubber layer.
HIGH TEMPERATURE FLOW-LINE INSULATION

The present invention claims priority on United States Provisional Patent Application Serial No. 61/683,498 filed August 15, 2012, which is incorporated herein by reference.

The present invention is directed to a pipe or flow-line, more particularly to a pipe or flow-line suitable for operation at temperatures in excess of 150°C, and still more particularly to a pipe or flow-line suitable for operation at temperatures in excess of 150°C and which pipe or flow-line includes a high temperature thermoplastic or rubber insulator, one or more layers of polyolefin and/or polyolefin foam, and an outer polyolefin and/or rubber layer.

BACKGROUND OF THE INVENTION

The discovery of new hydrocarbon reserves are becoming more and more rare in the conventional offshore. As such, the petroleum industry is looking into new hydrocarbon reserves perspectives located in the deep sea (e.g., from 500m and 1500m) and the ultra-deep sea (e.g., from 1500m and 3000m). Thus, one of the currently most challenging projects in the petroleum industry consists of exploiting oil resources at great depths, wherein production infrastructures are submitted to high hydrostatic pressures (e.g., up to 300bar) and to low external temperatures (e.g., about 4°C at 3000 m). To limit heat losses so as to avoid the formation of hydrate and wax plugs inside deep-sea production flow-lines or risers under such pressure and temperature conditions, even during production shutdowns, the pipelines need to be thermally insulated. One of the most efficient types of thermal insulation systems is the use of a multilayered structure made of several materials of different thicknesses directly applied to the external surface of the steel pipe. Materials currently used in thermal insulated multilayered systems for deep-sea applications include massive polymers and syntactic foams composed of hollow glass microspheres embedded in a polymer matrix. These composites must combine thermal insulation function and low buoyancy while providing good compressive strength.

One prior art solution to the problem of preventing blocking of the flow-lines is to cover the flow-lines with an external coating that adheres to the flow-lines and is made from a thermally-insulative material which also has the mechanical strength needed to withstand the high hydrostatic pressure encountered at great depths. In particular, composite products based on an epoxy resin, polyurethane or polypropylene for example, are used for this coating. Such
products are manufactured and sold by companies including Isotub (France), Balmoral Webco Pipeline Systems (Great Britain) and Bredero Price (USA). By adjusting the composition of the coating, it is possible to vary the density (and therefore the buoyancy), the mechanical strength, the coefficient of heat transfer, and the thermal conductivity of the coating. The high mechanical strength of the coating needed at great depths was accompanied by a great increase in the density of the material used. This increase in density has an adverse effect on the coating’s thermal insulation properties. The thickness of the coating must then be further increased to obtain the required thermal insulation, which renders this solution excessively costly at great depths. Also, the resistance to abrasion of such a coating is insufficient to allow flow-line installation by towing the flow-lines along the sea floor.

Another technique known for protecting underwater flow-lines at great depths is to surround the flow-lines with a conventional tubular protective carrier pipe capable of resisting the hydrostatic pressure. The flow-lines protected by such a carrier pipe may be then installed by towing them into place. The carrier pipe can contain a plurality of flow-lines, each having a thin thermal insulation coating of low density (polyurethane foam, polyethylene foam, glass wool, mineral wool, etc.). At very great depths, the steel carrier pipe cannot resist the hydrostatic pressure unless its thickness is increased out of all proportion, which increases the weight per linear meter to the detriment of buoyancy, which is necessary for towing it into place. In this latter case, which is well known in the art, the internal space of the sleeve between the coated flow-line(s) and the sleeve itself is filled with an inert gas, for example, nitrogen. The pressure of nitrogen in the sleeve must then be maintained throughout the service life of the flow-lines, which can be twenty years or more. This constraint is costly because the initial pressurization is costly and maintenance is difficult because the nitrogen slowly diffuses through the welds in the carrier pipe. Moreover, the pressure must be established during the construction of the pipeline on land, for example, on a beach. The high pressure required can then cause a dangerous explosion of the carrier pipe. It is therefore necessary to increase the thickness of the carrier pipe which is detrimental to the buoyancy of the assembly, which is necessary for towing it into place, as already mentioned.
More and more oil and gas is being recovered in deeper, colder water. Deep-sea production systems, which use viscosity reducing chemicals, require a dedicated line to transport such chemicals to the wellhead. This, combined with the fact that the cost of insulating pipelines typically increases with depth, indicates that insulated pipelines are most expensive where the alternatives are least attractive.

Prior art insulation used in undersea pipelines includes porous plastic foam (such as polyurethane foam) and multilayer insulation (primarily polypropylene and polypropylene foam insulations, also known as "wet insulation"). The use of syntactic foams has been discussed as an insulator suitable for deep-sea pipeline insulation. As known, syntactic foams are composite materials in which hollow structures, such as microspheres, are dispersed in a resin matrix. However, in any practical manufacturing situation, microspheres cannot be introduced into the foam in a sufficient quantity to provide the requisite thermal insulation. In addition, the resin binders which hold the microspheres in conventional syntactic foams are too rigid to sustain the bending associated with conventional pipeline laying techniques.

More recent discoveries have resulted in the production of oil with higher temperatures, and this fact, along with the cost of injecting viscosity modifiers at greater distances, has generated the need for higher temperature wet insulations as an alternative to costly "pipe in pipe" insulation. The greater depths of current discoveries and the resulting higher pressures create the need for thicker walls and heavier pipe, such that traditional pipe in pipe high temperature insulation cannot be used while deploying the risers and flow-lines from currently existing lay barges.

Touzel, et al. discloses the use of a separate high temperature insulation layer in U.S. Patent No. 6,075,452; however, no description of such a layer is provided, nor a viable solution identified or suggested. Information about prior art coatings for pipes is disclosed in U.S. Patent Nos. 7,091,277; 6,827,110; 6,213,157; 6,075,452; 6,058,979; 5,939,145; 4,660,861; and Experimental testing and modelling of an industrial insulated pipeline for deep sea application, Nadege Bouchonneaua, Valerie Sauvant-Moynota, Dominique Choqueuseb, Francois Grosjeana, Emmanuel Poncetc, and Dominique Perreuxc, Journal of Petroleum Science and Engineering, August 2010, Volume 73, Issues 1-2, Pages 1-12, Bredero show thermotite product brochure,

In view of the new production environments for oil and gas extraction and the current state of the art of pipes or flow-lines, there is a need for an insulator which provides sufficient insulation for deep-sea operations at temperatures above 150°C, and yet is flexible enough to withstand the bending associated with pipe laying operations.

SUMMARY OF THE INVENTION

The present invention is directed to a pipe or flow-line suitable for operation at temperatures in excess of 150°C that overcome the deficiencies of prior art pipes and flow-lines. In one non-limiting embodiment of the invention, the pipe or flow-line is suitable for operation at temperatures in excess of 150°C and which pipe or flow-line includes a high temperature thermoplastic or rubber insulator, one or more layers of polyolefin and/or polyolefin foam, and an outer polyolefin and/or rubber layer. In another and/or alternative non-limiting embodiment of the invention, the pipe or flow-line is an underwater pipeline for transferring products such as, but not limited to, petroleum products (e.g., liquid petroleum products, gas petroleum products, liquid-gas petroleum products, etc.). In still another and/or alternative non-limiting embodiment of the invention, the pipe or flow-line is designed to be laid on or near the sea floor at great depths, i.e., at depths of several hundred to several thousand meters or more. At such depths, underwater wells usually produce liquid hydrocarbons, gaseous hydrocarbons and water simultaneously. At the low temperatures encountered at these great depths, the multi-phase mixture causes the formation of gas hydrates and paraffins that can block the flow-lines in which it flows. The resistance to the flow of liquid products such as, but not limited to, oil increases as the temperature decreases. This problem can be reduced by using thermally-insulated pipelines.

However, insulation products suitable for application at temperatures exceeding 150°C have not been developed or described to date.

In one non-limiting aspect of the present invention, there is provided an insulation system for a pipe or flow-line. The insulation system generally includes a plurality of different layers; however, this is not required. The insulation system includes one or more layers selected from
the group of an adhesive layer, a high temperature insulation system, a secondary insulation layer, and a shielding layer. When the insulation system includes two or more layers, the two or more layers can be the same or different. If two or more of the layers are the same, layers having the same composition are separated by a layer having a different composition. The thickness of the layers can be the same or different. In one non-limiting embodiment of the invention, the insulation system is at least a four-layer system that includes one or more layers selected from the group of 1) an adhesive, tie and/or corrosion resistant layer (e.g., a high temperature epoxy material, a thermoplastic material, a silicone material, a rubber material, a fluoropolymer material, etc.), 2) a first high temperature insulation system (e.g., a thermoplastic polymer material, a rubber material, and a thermoplastic flouroelastomer material, etc.), 3) a secondary insulation system (e.g., a thermoplastic polymer material, a rubber material, and a thermoplastic flouroelastomer material, etc.) and, 4) an outer solid shielding layer (e.g., polyolefin (PP) layer, etc.).

In another and/or alternative non-limiting aspect of the present invention, the high temperature insulation system includes the first high temperature insulation system and any optional secondary insulation system. Generally, the composition of the high temperature insulation system is different from the composition of the an adhesive, tie and/or corrosion resistant layer and the outer solid shielding layer; however, this is not required. In one non-limiting embodiment of the invention, the first high temperature insulation system includes one or more layers of polyether-sulfone (PESU) and/or polyphenyl-sulfone (PPSU) which can be used to provide high temperature protection to the corrosion barrier. The high temperature insulation system and outer solid shielding layer, while designed for high temperature use, can also be used in environments that are below HOC. The polysulfone systems of the high temperature insulation system, when used, are designed to be used for their insulation and barrier properties at temperatures from about 140°C to 210°C. Solid, syntactic, and/or foamed PPSU and PESU can be used in the high temperature insulation system, depending on the hydrostatic pressure and specific design requirements. In one non-limiting specific configuration, a polyphenyl-sulfone (PPSU) layer and/or polyether-sulfone (PESU) can be used as a base coat on the pipe or flow line. The thickness of the PPSU and/or PESU layer is generally at least about 2
mm, typically at least about 5 mm, and more typically about 5-100 mm; however, other thicknesses can be used. The PPSU and/or PESU layer can be applied via side extrusion onto the pipe or flow-line; however, the layer can be applied by other or additional means (e.g., spray coated, painted, dipped, etc.). When a secondary insulation system is used, the secondary insulation system can be formed of the same or different material from the first high temperature insulation system. In one non-limiting embodiment, the secondary insulation system, when used, includes polypropylene and/or polyurethane insulation. The secondary insulation system can be applied onto the layer of solid, foam, and/or syntactic foam PPSU and/or PESU, and a polyolefin outer shield can be applied to the one or more layers of polypropylene and/or polyurethane insulation. The secondary insulation system can be solid, foam, and/or syntactic foam. The thickness of the layer of solid polypropylene and/or polyurethane insulation, when used, is generally at least about 1 mm, typically at least about 2 mm, and more typically about 5-40 mm; however, other thicknesses can be used. The thickness of the layer of solid, foam, and/or syntactic foam polypropylene and/or polyurethane insulation, when used, is generally at least about 2 mm, typically at least about 5 mm, and more typically about 5-200 mm; however, other thicknesses can be used. When both a layer of solid insulation and a layer of solid, foam, and/or syntactic foam insulation are used in the secondary insulation system, the thickness of the solid layer is generally less than the thickness of the syntactic or foam layer; however, this is not required. Also, when both a layer of solid insulation and a layer of solid, foam, and/or syntactic foam insulation are used, the layer of solid, foam, and/or syntactic foam insulation is generally coated on or about the solid layer insulation; however, this is not required. The thickness of the layer of outer shield (e.g., polyolefin outer shield, etc.) is generally at least about 1 mm, typically at least about 2 mm, and more typically about 5-40 mm; however, other thicknesses can be used. Generally, the thickness of the layer of outer shield is less than at least one of the layers of the first high temperature insulation system (e.g., PPSU and/or PESU layer, etc.); however, this is not required. Generally, the thickness of the layer of outer shield is less than the layer of syntactic or foam insulation of the secondary insulation system, when used; however, this is not required.
In still another and/or alternative non-limiting aspect of the present invention, the outer surface of the pipe or flow-line can be optionally treated prior to applying any layers to the outer surface of the pipe or flow-line. Such optional treatments include flame oxidation and/or surface preheating.

In yet another and/or alternative non-limiting aspect of the present invention, one or more layers of an adhesive or tie layer and/or corrosion barrier can be optionally applied to the outer surface of the pipe or flow-line prior to applying the one or more layers of PPSU and/or PESU about the pipe. In one specific non-limiting example, under a PPSU and/or PESU coating layer is applied an adhesive or tie layer and/or corrosion barrier. The adhesive or tie layer and/or corrosion barrier can be applied to the outer surface of the pipe or flow-line via side extrusion; however, the layer can be applied by other or additional means (e.g., spray coated, painted, dipped, etc.). The thickness of the adhesive or tie layer and/or corrosion barrier is generally at least about 0.1 mm, typically at least about 0.5 mm, and more typically about 0.5-20 mm; however, other thickness can be used. The layer can only be an adhesive or tie layer, only be a corrosion barrier, or be a combination of an adhesive or tie layer and a corrosion barrier. Non-limiting examples of the adhesive or tie layer and/or corrosion barrier include an epoxy, thermoplastic, silicone, rubber and/or fluoropolymer. Non-limiting specific examples include an epoxide (epoxy-silixane copolymer), a solvent-based high temperature (PPSU) adhesive mixture, and/or reactive adhesives (e.g., polysilazanes and/or BisPhenol-A, etc.).

In still yet another and/or alternative non-limiting aspect of the present invention, solid and/or hollow microspheres (e.g., ceramic and/or glass microspheres, etc.) can optionally be one or more of the PPSU and/or PESU coating layers to improve the tear strength and/or tensile strength and/or elongation of the PPSU and/or PESU syntactic insulators.

One non-limiting object of the present invention is to provide an insulation system of a pipe or flow-line that is suitable for deep-sea operation.

Another non-limiting object of the present invention is to provide a method for manufacturing an insulation system of a pipe or flow-line that is suitable for deep-sea operation.

Still another non-limiting object of the present invention is to provide a pipe or flow-line that is suitable for deep-sea operations at elevated temperatures above 140C.
Yet another non-limiting object of the present invention is to provide a pipe or flow-line that has sufficient insulation for deep-sea operations at temperatures above HOC, and yet is flexible enough to withstand the bending associated with pipe laying operations.

Still yet another non-limiting object of the present invention is to provide an insulated pipe or flow-line that includes an insulation system having a plurality of different layers.

Another non-limiting object of the present invention is to provide an insulated pipe or flow-line that includes an insulation system having two or more layers selected from the group of an adhesive layer, a high temperature insulation system, a secondary insulation layer, and a shielding layer.

Still another non-limiting object of the present invention is to provide an insulated pipe or flow-line that includes an insulation system having at least four layers selected from the group of 1) an adhesive layer, 2) a high temperature insulation system (e.g., PESU layer and/or PPSU layer, etc.), 3) a layer of secondary insulation (e.g., polypropylene insulation, polyurethane insulation, etc.), 4) an outer solid shielding layer (e.g., polyolefin (PP) layer, etc.).

Yet another non-limiting object of the present invention is to provide an insulated pipe or flow-line where the outer surface of the pipe or flow-line is optionally treated prior to applying any layers to the outer surface of the pipe or flow-line.

Still yet another non-limiting object of the present invention is to provide an insulated pipe or flow-line that includes an insulation system having one or more layers of an adhesive or tie layer and/or corrosion barrier optionally applied to the outer surface of the pipe or flow-line prior to applying one or more layers of PPSU and/or PESU about the pipe.

Another non-limiting object of the present invention is to provide an insulated pipe or flow-line that includes an insulation system having microspheres (e.g., ceramic and/or glass microspheres, etc.) optionally included in one or more of the PPSU and/or PESU coating layers to improve the tear strength and/or tensile strength and/or elongation of the PPSU and/or PESU syntactic insulators.

These and other objects, features and advantages of the present invention will become apparent in light of the following detailed description of preferred embodiments thereof, as illustrated in the accompanying drawings.
BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional illustration of a non-limiting insulated pipeline in accordance with the present invention; and,

FIG. 2 is a flow chart illustrating one non-limiting manufacturing process of applying insulation to a pipe in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings wherein the showings are for the purpose of illustrating embodiments of the invention only and not for the purpose of limiting the same, Figs. 1-2 illustrate non-limiting embodiments of the insulated pipe and method for manufacturing the insulated pipe in accordance with the present invention. The present invention is directed to a pipe or flow-line suitable for operation at temperatures in excess of 150°C that overcome the deficiencies of prior art pipes and flow-lines. The pipe or flow-line is suitable for use as an underwater pipeline for transferring products such as, but not limited to petroleum products (e.g., liquid petroleum products, gas petroleum products, liquid-gas petroleum products, etc.). The pipe or flow-line can be designed to be laid on or near the sea floor at great depths, i.e., at depths of several hundred to several thousand meters or more.

One non-limiting objective for the invention is the use of a high temperature insulation layer on a flow-line or other pipe to reduce the temperature from 170-210°C to approximately HOC, wherein traditional PP or PU insulation systems can be applied. The system may optionally utilize a high temperature corrosion barrier, made from either the same material as the high temperature insulation, a siloxane or epoxide, or rubber material. Various other polymers can optionally or additionally be chosen.

In one non-limiting arrangement, the system includes a high temperature epoxy or PPSU-containing base corrosion and adhesive layer, a PPSU massive layer for the high temperature insulation layer to reduce temperature to approximately 150°C, and a polypropylene wet insulation system of sufficient insulation value to further reduce the temperature to that of the seawater. Alternatively, a PPSU foam, a multilayer PPSU/PESU, or solid, foam and/or syntactic foam system could be produced to optimize performance and/or weight for the different temperature regimes to create a two- to four-layer high temperature insulation underlayment.
system, followed by a two- to five-layer traditional insulation system applied over the high
temperature corrosion barrier/insulation system.

Referring now to FIG. 1, there is illustrated a cross section of one non-limiting insulated
pipe system 100 in accordance with the present invention. The insulating pipeline system
includes an inner pipe 110. The size, shape and composition of the pipe is non-limiting.
Generally, the pipe is formed of a metal material (e.g., steel, metal alloys, etc.); however, it can
be appreciated that the pipe can be formed of other materials (e.g., composite materials, etc.).
The pipe generally has a circular cross-sectional shape and a diameter of about 6 to 22 inches
and a wall thickness typically about 0.5 to 2 inches; however, other diameters and thickness can
be used. The pipe 110 is commonly referred to as a "flow-line" or "riser" because oil or gas, or
in most cases a combination of the two, pass through the pipe and rise to the surface.

To protect pipe 110 from the corrosive effects of sea water, an anti-corrosion barrier layer
130 (e.g., plastic film, paint-like coating, etc.) can optionally be used to partially or fully cover
the exterior or outer surface of the pipe. The anti-corrosion barrier, when used, is generally
bonded to the pipe directly, or through a solvent-applied or thermally-cured adhesive or epoxide
coating 120. The anti-corrosion barrier, which is typically PPSU, can optionally be thickened to
serve as an initial insulation for temperatures up to 210C; however, other or additional materials
can be used. One or more insulating layers 140, 150, 160, 170 can be applied to anti-corrosion
barrier layer 130. As illustrated in Fig. 1, a high temperature insulation layer formed of a layer
of PESU foam and/or PPSU foam or syntactic foam 140 and a layer of a dense polypropylene
insulating layer or a foamed or syntactic polypropylene insulating layer 150 are applied about
anti-corrosion barrier layer 130. Also, a polyolefin (PP) insulation layer 160 can be placed over
the polypropylene insulating layer 150. Over the polyolefin (PP) insulation layer 160 is applied
a tough, durable shield layer 170, which can include polypropylene. The durable shield layer
170 hermetically seals the insulating layers and protects the insulation from damage during
handling and installation.

In general, the barrier and insulating layers are applied as melts through such processes as
side extrusion, although those skilled in the art could devise injection molding or even tape-
wrapping processes as alternative to the side extrusion process. To insure adhesion, the layers
can be applied to hot underlayments, where the heat is derived from preheating the pipe (to below the temperature where its properties degrade, typically 350-400°F), and/or via flame, RF, IR, or other heating method. As an alternative, solvent adhesives can be used, or high temperature adhesives such as epoxies can be used.

One of the difficulties in working with high temperature amorphous thermoplastics and polypropylene is developing adequate bonding between different layers and the material of the pipe (e.g., steel, etc.). In addition to preheating the pipe material and the interlayers, use of solvent adhesives (e.g., PPSU in methylene chloride, etc.) combined with hot air drying, the use of contact rubber cements, polysiloxane intermediates, and/or epoxide primers/adhesives can be used at the pipe interface and between one or more of layers 120, 130, 140, 150, 160, 170. These techniques can be identified by those skilled in the art. Other options include functionalization of the surfaces, such as through flame oxidation or some other process, but also or alternatively through the use of oxidizing acids such as chromic acid or nitric acid. Other options for processing of the high temperature barrier and insulation layers include flame spray application, compression and injection molding, and formation of solid sections followed by adhesive application or rubber impregnation, followed by the PP traditional wet insulation application.

The requirements of the high temperature corrosion barrier and insulation system are high hydrolytic resistance and stability in hot water to 170-210°C (maximum use temperature), adequate ductility/elongation to failure, and decent creep resistance and property stability to the maximum use temperature. High temperature rubbers, PPSU polysulfones, PESU polysulfones, and/or filler/toughened high temperature epoxies all have the potential for use in the high temperature regions, while the PPSU and PESU are the desired components for use in the present invention.

Other alternatives and enhancements to the PPSU insulation system include the use of thermal spray aluminum cathodic layers, and/or the addition of aluminum or silicate corrosion inhibitors/cathodic protection materials to the base layers. Zinc additions are not desirable for the higher temperature systems, but aluminum and silicate systems are suitable for enhancing corrosion resistance under the higher temperature conditions of deepwater flow-lines and risers.
Generally, the ends of the pipe sections, which may be 40ft "single" or 80ft "doubles", can be left open to allow for welding. These open ends generally are welded on the lay barge, and a joint coating is typically applied to prevent corrosion and to provide insulation in the joint areas. Injection molding and flame/thermal spray, as well as rubber impregnation of preformed insulation blocks (alone or in combination with one another), are hereby described as suitable techniques for applying joint coatings and joint insulation systems. In one non-limiting embodiment for joint coating solutions, a corrosion barrier is applied using flame spray, followed by the application of PPSU or PESU insulation via compression molding or injection molding. A final outer shield layer can be then applied via tape-wrapping or flame spray, if so desired. Alternatively, a flame spray corrosion barrier can be mated to preformed insulation (quadrants or half-shells), followed by an outer shield layer.

One non-limiting overall process of applying a six-layer high temperature insulation system to a pipe is illustrated in Fig. 2. The pipe can optionally be grit blasted prior to being coated with the insulation system. The pipe can be optionally preheated prior to being coated with the insulation system. The preheat temperature is generally about 60-200C. Although the step is not shown, an anti-corrosion barrier layer formed of a plastic film or paint-like coating can optionally be applied to the exterior or outer surface of the pipe. An adhesive primer can optionally be applied to the outer surface of the pipe. A layer of PPSU is applied about the outer surface of the pipe. The layer of PPSU can be applied by an extrusion process. The adhesive primer, when used, facilitates in securing the layer of PPSU about the outer surface of the pipe. A flame or IR is applied to the layer of PPSU to facilitate in securing the layer about the pipe. A layer of PESU foam and/or syntactic foam is applied about the layer of PPSU. The layer of PESU can be applied by an extrusion process. A flame or IR is applied to the layer of PESU to facilitate in securing the layer of PESU to the layer of PPSU. A layer of polypropylene is applied about the layer of PESU. Thereafter, a layer of foam or syntactic polypropylene is applied about the layer of polypropylene. An outer layer which can be formed of polyolefin is applied out the foam or syntactic polypropylene. After all of the layers are applied, the pipe and the various coated layers are inspected.
It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained, and since certain changes may be made in the constructions set forth without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense. The invention has been described with reference to preferred and alternate embodiments. Modifications and alterations will become apparent to those skilled in the art upon reading and understanding the detailed discussion of the invention provided herein. This invention is intended to include all such modifications and alterations insofar as they come within the scope of the present invention. It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention, which, as a matter of language, might be said to fall there between. The invention has been described with reference to the preferred embodiments. These and other modifications of the preferred embodiments as well as other embodiments of the invention will be obvious from the disclosure herein, whereby the foregoing descriptive matter is to be interpreted merely as illustrative of the invention and not as a limitation. It is intended to include all such modifications and alterations insofar as they come within the scope of the appended claims.
What is claimed:

1. A high temperature insulation system for a pipe that is suitable for use at temperatures of at least about 140°C comprising:
   a) an initial coating layer that includes one or more materials selected from the group consisting of an adhesive material, a tie material, a corrosion resistant material and a corrosion barrier material, said initial coating applied on or about an outer surface of said pipe;
   b) a high temperature insulation system, said high temperature insulation system formed of one or more layers of material, said high temperature insulation system positioned on or about said initial coating layer, said high temperature insulation system including one or more materials selected from the group consisting of a thermoplastic polymer material, a rubber material, and a thermoplastic fluoroelastomer material; and,
   c) an outer layer, said outer layer positioned on or about said high temperature insulation system, and wherein an interface temperature between said outer layer and said high temperature insulation system is designed to be at least about 130°C.

2. The high temperature insulation system as defined in claim 1, wherein said initial coating layer has a thickness of at least about 0.1 mm.

3. The high temperature insulation system as defined in claim 1, wherein said initial coating layer includes one or more materials selected from the group consisting of a high temperature epoxy material, a thermoplastic material, a silicone material, a rubber material, and a fluoropolymer material.

4. The high temperature insulation system as defined in claim 2 or 3, wherein said initial coating layer includes one or more materials selected from the group consisting of a high temperature epoxy material, a thermoplastic material, a silicone material, a rubber material, and a fluoropolymer material.
5. The high temperature insulation system as defined in claim 1, wherein said high temperature insulation system has a thickness of at least about 5 mm.

6. The high temperature insulation system as defined in claims 2-4, wherein said high temperature insulation system has a thickness of at least about 5 mm.

7. The high temperature insulation system as defined in claim 1, wherein said outer layer includes a polyolefin material.

8. The high temperature insulation system as defined in claims 2-6, wherein said outer layer includes a polyolefin material.

9. The high temperature insulation system as defined in claim 1, wherein said high temperature insulation system includes a polyphenyl-sulfone layer, a polyether-sulfone layer, or combinations thereof.

10. The high temperature insulation system as defined in claims 2-8, wherein said high temperature insulation system includes a polyphenyl-sulfone layer, a polyether-sulfone layer, or combinations thereof.

11. The high temperature insulation system as defined in claim 9, wherein said high temperature insulation system includes polypropylene insulation, polyurethane insulation, or combinations thereof.

12. The high temperature insulation system as defined in claim 10, wherein said high temperature insulation system includes polypropylene insulation, polyurethane insulation, or combinations thereof.
13. The high temperature insulation system as defined in claim 1, wherein high temperature insulation system includes microspheres.

14. The high temperature insulation system as defined in claims 2-12, wherein high temperature insulation system includes microspheres.

15. A high temperature insulation system for a pipe that is suitable for use at temperatures of at least about 170°C comprising:
   a) an initial coating layer that includes one or more materials selected from the group consisting of an adhesive material, a tie material, a corrosion resistant material and a corrosion barrier material, said initial coating applied on or about an outer surface of said pipe, said initial coating layer having a thickness of about 0.2-5 mm, said initial coating layer includes one or more materials selected from the group consisting a polyphenyl sulfone material, a polyethersulfone material, an epoxide material, and a fluoropolymer based material;
   b) a high temperature insulation system, said high temperature insulation system positioned on or about said initial coating layer, said high temperature insulation system having a thickness of about 5-50 mm, said high temperature insulation system formed of a solid material, a syntactic material, a foam material, or combinations thereof, said high temperature insulation system includes one or more materials selected from the group consisting of a thermoplastic polyethersulfone material, a polyphenyl sulfone material, and a thermoplastic fluoroelastomer material; and,
   c) an outer layer, said outer layer positioned on or about said high temperature insulation system, said outer layer including a polyolefin material, and wherein an interface temperature between said outer layer and said high temperature insulation system is designed to be from about 130-150°C.

16. A four- to eight-layer high temperature insulation system for a pipe comprising:
   a) an initial coating layer that includes one or more materials selected from the group consisting of an adhesive material, a tie material, a corrosion resistant material and a
corrosion barrier material, said initial coating applied on or about an outer surface of said pipe, said initial coating layer having a thickness of about 0.5-5 mm;

b) a first high temperature insulation system, said high temperature insulation system positioned on or about said initial coating layer, said high temperature insulation system having a thickness of about 5-50 mm, said high temperature insulation system formed of a solid material, a syntactic material, a foam material, or combinations thereof, said high temperature insulation system includes one or more materials selected from the group consisting of polyethersulfone material and a polyphenylenesulfone material;

c) a first secondary insulation system, said first secondary insulation system positioned on or about said high temperature insulation system, said first secondary insulation system having a thickness of about 10-100 mm, said first secondary insulation system formed of a solid material, a syntactic material, a foam material, or combinations thereof, said first secondary insulation system including a polypropylene material; and,

d) an outer layer, said outer layer positioned on or about said high temperature insulation system, said outer layer including a polyolefin material, said outer layer having a thickness of about 2-5 mm.

17. A high temperature insulation system for a pipe comprising:

a) an initial coating layer that includes one or more materials selected from the group consisting of an adhesive material, a tie material, a corrosion resistant material and a corrosion barrier material, said initial coating applied on or about an outer surface of said pipe, said initial coating having a thickness of about 0.5-8 mm, said initial coating including one or more materials selected from the group consisting of a high temperature thermoplastic material, a fluoroelastomer material, a silicone material, a rubber material, and a high temperature epoxide material; and,

b) a high temperature insulation system, said high temperature insulation system formed of one or more layers of material, said high temperature insulation system positioned on or about said initial coating layer, said high temperature insulation system including one or more
materials selected from the group consisting of a thermoplastic material and a fluoropolymer material.

18. A method for insulating a pipe comprising:
   a. providing a pipe having an outer surface;
   b. applying a high temperature insulation system on or about said outer surface of said pipe, said high temperature insulation system formed of one or more layers of material, said high temperature insulation system including one or more materials selected from the group consisting of a thermoplastic polymer material, a rubber material, and a thermoplastic fluoroelastomer material; and,
   c. applying an outer layer on or about said high temperature insulation system, and wherein an interface temperature between said outer layer and said high temperature insulation system is designed to be at least about 130°C.

19. The method as defined in claim 18, wherein at least one of said layers of said high temperature insulation system is applied by a side extrusion or injection molding technique.

20. The method as defined in claim 18, wherein said initial coating layer has a thickness of at least about 0.1 mm.

21. The method as defined in claim 19, wherein said initial coating layer has a thickness of at least about 0.1 mm.

22. The method as defined in claim 18, wherein said initial coating layer includes one or more materials selected from the group consisting of a high temperature epoxy material, a thermoplastic material, a silicone material, a rubber material, and a fluoropolymer material.
23. The method as defined in claims 19-21, wherein said initial coating layer includes one or more materials selected from the group consisting of a high temperature epoxy material, a thermoplastic material, a silicone material, a rubber material, and a fluoropolymer material.

24. The method as defined in claim 18, wherein said high temperature insulation system has a thickness of at least about 5 mm.

25. The method as defined in claims 19-23, wherein said high temperature insulation system has a thickness of at least about 5 mm.

26. The method as defined in claim 18, wherein said outer layer includes a polyolefin material.

27. The method as defined in claims 19-25, wherein said outer layer includes a polyolefin material.

28. The method as defined in claim 18, wherein said high temperature insulation system includes a polyphenyl-sulfone layer, a polyether-sulfone layer, or combinations thereof.

29. The method as defined in claims 19-27, wherein said high temperature insulation system includes a polyphenyl-sulfone layer, a polyether-sulfone layer, or combinations thereof.

30. The method as defined in claim 28, wherein said high temperature insulation system includes polypropylene insulation, polyurethane insulation, or combinations thereof.

31. The method as defined in claim 29, wherein said high temperature insulation system includes polypropylene insulation, polyurethane insulation, or combinations thereof.
32. The method as defined in claim 18, wherein high temperature insulation system includes microspheres.

33. The method as defined in claims 19-31, wherein high temperature insulation system includes microspheres.
FIG. 1
FIG. 2