

TEMPERATURE-CONTROLLED SORPTION SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to a temperature control for sorption systems.

Description of the Related Art

 Sorption systems based on the sorption principle are described, for example, in the U.S. patent application Serial No. 16/888,483 (U.S. Publication 2020-0378656), filed on May 29, 2020, which is incorporated herein by reference in its
10 entirety.

 A sorption system is a device that raises heat from a lower temperature level to a higher temperature level by vaporizing a working fluid in an evaporator and sorbing it in a sorbent container that contains a sorbent. The evaporator and the sorbent container are connected to one another by a steam channel. The
15 evaporation of the liquid working medium to a vapor working medium in the evaporator requires heat. If not enough heat flows in, the evaporator cools down. The sorption of the working medium in the sorbent container in turn releases heat. This heat has to be dissipated. One use of a sorption system is as a sorption cooling system.

20 In order to keep the evaporation temperature at the required temperature level, the flow of the working fluid vapor through the steam channel must be regulated by means of a valve. The evaporator is housed in an insulated transport box while the sorbent container located outside the transport box can dissipate its sorption heat to the environment.

25 In sorption cooling systems, effective and reliable control of the valve flow rate is difficult, especially when the control has to work reliably for many days. Sorption cooling systems are increasingly being used for shipping temperature-sensitive goods, including medicines. The temperature of the transported goods must be in a very narrow temperature range, e.g. +2 to + 8 °C. The ambient temperatures
30 occurring during transport can naturally fluctuate rapidly and strongly. For example, when transporting certain vaccines, the vaccine storage space temperature may only fluctuate between + 2 °C and + 8 °C. The external temperatures can be between -25 °C and + 43 °C. The transport time can be more than 6 days. The power

consumption of the temperature control must be minimized over long transport times and preferably also during the previous storage times.

When transporting sorption cooling systems, strong vibrations and falls from high heights can occur. If sorption systems are used for temperature-controlled transport, the manufacturing and operating costs must be particularly low. It often happens that the cooling system can only be used for a single transport route. For logistical reasons, it is often not possible or useful to return the transport used to the originating source.

10 BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

Figure 1 is a schematic drawing of a sorption system in accordance with the present invention.

Figure 2 is a schematic cross sectional view of a valve for use with the sorption system of Figure 1 showing the valve in a closed position.

15 Figure 3 is a schematic cross sectional view of a temperature controller docked with the valve of Figure 2, showing the valve in the closed position.

Figure 4 is a schematic cross sectional view of a temperature controller docked with the valve of Figure 2, showing the valve in the opened position.

20 DETAILED DESCRIPTION OF THE INVENTION

The temperature controller of the present invention preferably provides a reusable temperature control for sorption systems that work in a vacuum. Preferably, the temperature controller can actuate a valve that is located in a separate vacuum system. The pre-selectable evaporation temperature of the sorption system should be adhered to. Preferably, it is possible to connect the temperature controller to exchangeable sorption systems with simple means. Preferably, the temperature controller should be reusable. Preferably, the temperature controller should be removable from the sorption systems with which used without use of tools and be just as easy to reconnect to a fresh sorption system without the use of tools.

30 A sorption system 1000 using a battery-operated temperature controller 1120 in accordance with the present invention is shown in Figure 1. The sorption system 1000 includes an evaporator 1001 in which a liquid working medium is absorbed in a fleece (not shown). As shown in Figure 2, the evaporator 1001 has a flexible,

vacuum-tight outer shell 1028 made of an upper flexible film 1030 and a lower flexible film 1032, which are sealed in a gas-tight manner at their adjoining seams by known sealing methods. The fleece is divided into four sections. The evaporator 1001 can be bent at contact lines 1004 of the sub-areas of the evaporator in order
5 for it to be inserted precisely into an insulated transport box or payload compartment (not shown). An electrical heating circuit 1007 may be inserted into the interior of the insulated transport box. The heating circuit 1007 is used to heat the interior of the insulated transport box when the ambient temperature within the box is below a required control temperature. A temperature sensor 1129 senses the temperature of
10 the evaporator 1001 surface and/or the air adjacent to the evaporator surface indicative of the evaporator surface temperature, and generates a temperature signal, and reports the temperature to the temperature controller 1120 via a communication channel 1006, which may be a wire or a wireless signal. In response to a sensed temperature being below the control temperature, the temperature
15 controller 1120 takes over the control and regulation of the heating circuit 1007. The temperature sensor may or may not form a portion of the temperature controller.

The evaporator 1001 is connected to a sorbent container 1002 via a steam flow channel 1003. Working medium steam can flow through the steam flow channel 1003 to the sorbent container 1002, provided that an intermediate valve 1010
20 (shown in Figure 2) is kept open by the temperature controller 1120. A granulated sorbent 1005 in the sorbent container 1002 may sorb the working medium vapor flowing in. The sorbent 1005 may contain, for example, zeolite, which stores the working medium vapor in its lattice structure. During sorption heat is released. The temperature controller 1120 operates the valve 1010 that is located in the steam flow
25 channel 1003 in response to the temperature measured by the temperature sensor 1129.

As described above, the valve 1010 is arranged between the evaporator 1001 and the sorbent container 1002. The valve 1010 and temperature controller 1120 are shown in greater detail in Figures 3 and 4.

30 In Figures 3 and 4, the temperature controller 1120 is shown removably docked to the valve 1010 using suitable contact surfaces 1121 and 1122 of the temperature controller. The lower contact surfaces 1122 can be designed to be foldable or displaceable relative to the upper contact surfaces 1121 to securely but removably, attach the temperature controller 1120 to the valve 1010 and hence the

flow channel 1003 of the sorption system 1000. While securely attached by the contact surfaces 1121 and 1122, the temperature controller 1120 is easily detachable from the valve 1010. This permits the selective separation of the temperature controller 1120 from the remainder of the sorption system 1000 and the reuse with the valve 1010 of a different sorption system unit. While the temperature controller 1120 may only move minimally during operation, nevertheless, it should be possible to detach the temperature controller 1120 quickly and without tools from the valve 1010 and to be able to dock it again just as quickly on a new sorption system. Figure 2 shows the valve 1010 with the temperature controller 1120 removed. The valve 1010 and the other portions of the sorption system 1000, other than the temperature controller 1120, are usually disposed of as a single-use product after being used or are reprocessed elsewhere, while the temperature controller 1120 may be reused several times with different units of the sorption systems.

Figure 3 shows the valve 1010 in a closed position with the temperature controller 1120 docked to the valve for use. The temperature controller 1120 includes an inflatable air bladder or pouch 1123, an air compressor 1124 operated by a motor 1130, an air outlet valve 1125 and an electrical control unit 1126, interconnected by an air line system 1132. The control unit 1126 optionally includes a pressure sensor 1127, the temperature sensor 1129, and a signal unit 1128. The control unit 1126 works with the temperature sensor 1129 to control the inflatable pouch 1123. Two exchangeable, electrical batteries 1140 are provided to power the temperature controller 1120. Preferably, the control unit 1126 includes a microcontroller mounted on an electronic circuit board, operatively connected to the temperature sensor 1129 and the air compressor 1124, and configured to read the temperature signal of the temperature sensor. The valve 1010 regulates the working medium vapor flow from the evaporator 1001 to the sorbent container 1002 (see Figure 1). By opening or closing the valve 1010, the cooling power of the sorption system 1000 is controlled and thus regulates the evaporation temperature. The inflatable pouch 1123 is used to actuate the valve 1010, which is located outside of the temperature controller 1120 and in the flow channel 1003 of the sorption system 1000, and in a separate vacuum system. The temperature controller 1120 is reusable with sorption systems that work in a vacuum. The temperature controller 1120 can precisely adhere to a pre-selected evaporation temperature of the sorption system 1000.

The flow channel 1003 is formed by overlapping, gas-permeable upper and lower spacer grids 1020 and 1022, respectively. The upper and lower spacer grids 1020 and 1022 are enclosed in a gas-tight manner by the upper flexible film 1030 and the lower flexible film 1032 of the vacuum-tight outer shell 1028. In the case of
5 sorption systems that operate under vacuum, the upper and lower flexible films 1030 and 1032 are pressed onto the upper and lower spacer grids 1020 and 1022, respectively, by external air pressure. The vapor of the gaseous working medium flows through the flow-open spacer grids 1020 and 1022.

The valve 1010 includes a mushroom-shaped sealing element 1040 having
10 circular sealing plate 1050 connected to an upwardly extending plunger 1060 with a upper end portion 1061. The sealing plate 1050 has a circumferentially extending and upwardly projecting seal portion 1062 that is pressed into sealing engagement with a lower side of a flat silicone seal 1070 when the valve is in the closed position as shown in Figure 3. It is noted that the seal 1070 may be made from suitable
15 materials other than silicone. The silicone seal 1070 has a flow opening 1072 through which the plunger 1060 upwardly extends. The upper side of the silicone seal 1070 is in turn pressed onto a middle flexible film 1080, which contains a flow opening 1090 aligned with the opening 1072 of the silicone seal 1070, and through which the plunger 1060 upwardly extends. The upper spacer grid 1020 also has a
20 flow opening 1021 aligned with the opening 1072 of the silicone seal 1070 and the opening 1090 of the middle flexible film 1080, and through which the plunger 1060 extends.

The outer perimeter portion of the middle flexible film 1080 is sealed with the upper flexible film 1030 in such a way that the flow openings 1072 and 1090 provide
25 the only flow path for the working medium vapor to reach the upper spacer grid 1020. To stiffen the valve 1010, a plastic support plate 1100, which is also perforated, is positioned above the middle flexible film 1080 and coplanar with the silicone seal 1070 and middle flexible film 1080, and has a flow opening 1102 aligned with the opening 1072 of the silicone seal 1070 and the opening 1090 of the
30 middle flexible film 1080, and through which the plunger 1060 extends. Another plastic support plate 1110 is positioned above and coplanar with the upper spacer grid and has an opening 1112 aligned with the opening 1072 of the silicone seal 1070, the opening 1090 of the middle flexible film 1080, the opening 1102 of the support plate 1100, and the opening 1021 of the upper spacer grid 1020, and

through which the plunger 1060 extends. The opening 1112 of the plastic support plate 1110 is of a reduced size compared to openings 1072, 1090 and 1102 to facilitate guiding of the plunger 1060 as it moves up and down during operation.

It is noted that the lower flexible film 1032 is positioned below the bottom of
5 the sealing plate 1050. As such, when under a vacuum within the steam flow channel 1003, the lower flexible film 1032 presses upward on the sealing plate. The upper flexible film 1030, on the other hand under such a vacuum, presses downward on the mushroom-shaped upper end portion 1061 of the plunger 1060. The closing force that acts between the silicone seal 1070 and the seal portion 1062 of the
10 sealing plate 1050 is thus proportional to the difference between the respective areas of the sealing plate 1050 and the upper end portion 1061 of the plunger 1060. The effective closing force on the sealing element 1040 may therefore be designed by choosing the geometry of these two portions of the plunger 1060. In the illustrated embodiment, the valve 1010 is designed to normally be in the closed
15 position as shown in Figure 3.

To open the valve 1010 to the opened position shown in Figure 4 and open the flow opening 1072 of the silicone seal 1070, the upper end portion 1061 of the plunger 1060 is pushed downward sufficient to move the seal portion 1062 of the sealing plate 1050 downward to a position below and spaced away from the silicone
20 seal and hence out of sealing engagement with the silicone seal 1070. To close the flow opening 1072, only the applied opening force needs to be reduced sufficiently to permit the seal portion 1062 of the sealing plate 1050 to move upward into fluid sealing engagement with the silicon seal 1070. The valve 1010 is therefore always closed when no additional downward force acts on the upper end portion 1061 of the
25 plunger 1060. A force is therefore only required when operating the sorption system 1000. A separate locking of the valve 1010 is not necessary to keep the valve 1010 closed. The locking is maintained by the pressure difference between the vacuum within the steam flow channel 1003 and the external ambient air pressure.

As shown in Figure 3, the inflatable air pouch 1123 is positioned between a
30 stationary interior upper wall of the temperature controller 1120 and a moveable pressure plate 1131. Preferably, the pressure plate 1131 is a rigid plate. To move the valve 1010 to the opened position shown in Figure 4 from the closed position shown in Figure 3, the air compressor 1124 of the temperature controller 1120, in response to a signal from the control unit 1126, pumps air into the line system 1132

until the pressure sensor 1127 responds, or until a preset pressure is reached, or until a prespecified period of time ends. The air pressure supplied by the air compressor 1124 via the line system inflates the air pouch 1123, causing the air pouch to expand and press downward on the moveable pressure plate 1131, which
5 moves the pressure plate downward into downward driving engagement with the upper end portion 1061 of the plunger 1060. The pressure plate 1131 is preferably a torsion-resistant, glass fiber reinforced plate having a relatively large area such that to move the plunger 1060 sufficiently downward to open the valve 1010, the air pressure in the line system 1132 may be kept at less than 300 hPa. A pressure of
10 approximately 250 hPa and an effective plate area of only 20 cm² results in a force of about 50 N. Since the valve 1010 is fixed in position relative to the temperature controller 1120 by the contact surfaces 1121 and 1122, and cannot evade the pressure, the valve plate 1050 is moved downward and separates from the silicone seal 1070 sufficiently to be out of sealing engagement with the silicone seal and
15 presses the flexible upper flexible film 1030 located above the mushroom-shaped upper end portion 1061 of the plunger 1060 downward, overcoming the upward force being applied to the sealing plate 1050 of the sealing element 1040 of the valve 1010 by the external ambient air pressure. This opens the steam flow channel 1003 and provides a vapor channel indicated by the arrows 1133 in Figure 4, permitting vapor
20 to flow along the vapor channel from the evaporator 1001 to the sorbent container 1002.

As soon as the control unit 1126 gives a signal to close, the air outlet valve 1125 opens and pressurized air within the pouch 1123 may flow out of the pouch, thus allowing the pouch to contract and remove the downward force being applied to
25 the upper end portion 1061 of the plunger 1060, and allowing the sealing element 1040 to move upward and the valve 1010 to return to the normally closed position shown in Figure 3.

As discussed above, the inflatable pouch 1123 acts on the sealing element 1040, which is under vacuum. The flexible and inflatable pouch 1123 can exert its
30 force effect even with poorly coordinated contact points. When the pouch 1123 is depressurized, the temperature controller 1120 can easily be docked on the valve 1010 or dedocked.

The control unit 1126 is an electronic controller with logic and circuitry configured to receive data from one or more signal units, such as temperature

sensors or pressure sensors, and to output signals to one or more display units, lights such as LEDs, electrical heating circuits, and operable components, such as motor, air compressors, or valves. Preferably, the control unit 1126 activates the electrical heating circuit when the temperature measured by the temperature sensor

5 1129 falls below a preselected temperature. At least one battery may further be included for powering the temperature controller 1120 and the display units, preferably with the control unit indicating the state of the at least one battery using the display. The control unit 1126 can optionally includes memory for data storage and retrieval, with the microcontroller operatively connected to the memory. The

10 memory can be integrated into the control unit 1126 or separate from the control unit 1126. The memory can be, for example, flash memory or random-access memory. The control unit is powered by an energy source, such as the batteries 1140.

A temperature field or preset temperature setpoint can be stored in the control unit 1126, preferably in the memory, with which the temperature just measured at the

15 temperature sensor 1129 is compared. If the measured value is above the temperature setpoint, the pouch 1123 will inflate; if the measured value is below the temperature setpoint, the air outlet valve 1125 will be opened. If, on the other hand, the measured value lies within the temperature setpoint, neither the air compressor 1124 nor the air outlet valve 1125 is addressed. The temperature setpoint can

20 advantageously be set such that it allows the temperatures on the surface of the evaporator 1001 to fluctuate 1 degree Kelvin, between 5.5 °C and 6.5 °C, for example. Preferably, the control unit 1126 controls the state of inflation of the inflatable member to regulate the evaporation temperature in the evaporator 1001 to maintain the temperature measured by the temperature sensor 1129 at plus or

25 minus 1 degree Kelvin of the preselected temperature. The interior temperature of the insulated transport box within which the evaporator 1001 is housed is then always within the required temperature range of +2 to + 8 °C.

The control unit 1126 is powered by the batteries 1140. The state of charge of the batteries can be displayed via the signal unit 1128 at the time the sorption

30 system 1000 is put into operation and/or during the operating time. In particular, when starting the sorption process, the user can check the state of charge and replace the batteries 1140, if necessary. The current interior temperature can also be displayed during transport by means of coded flashing. The signal unit 1128 may be a light that flashes or it may be a display screen.

Advantageously, the control unit 1126 can not only control the air compressor 1124 and the air outlet valve 1125, but can also regulate the separate heating circuit 1007. If the temperature at the temperature sensor 1129 falls below a preset value, the electrical heating circuit 1007 is activated and the interior of the transport box is heated. This is particularly useful if, with very cold outside temperatures, the inside temperature would also drop below the required lower temperature limit of, for example, + 2 °C.

Advantageously, the control unit 1126 can also store the values measured by the temperature sensor 1129 during operation for later use. An electronic data memory integrated on the control unit 1126 can then output the values when the transport history is evaluated.

The pressure in the pouch 1123 can advantageously also be released manually. To this end, for example, the circuit to the air outlet valve 1125 can be opened manually using a button 1134. This may be important if, before the temperature controller 1120 is docked with a new sorption system, there is still pressure in the line system 1132 from the previous transport. Sufficient residual pressure may prevent the temperature controller 1120 from being pushed over the protruding plunger 1060.

The pressure sensor 1127 of the control unit 1126 measures the pressure in the air line system 1132. The pressure sensor 1127 makes it possible to readjust the pressure in the inflatable pouch 1123 even with slightly leaky lines or components. The air compressor 1124 then needs only run for a few moments until the pressure is built up again. The pressure sensor 1127 can also be used to open and close the valve 1010 in smaller step sequences. The valve 1010 can then function as a control valve and not be limited to only the states of being completely open and completely closed. The operating times of the compressor 1124 and the outlet valve 1125 can then be reduced considerably. This is particularly valuable if the temperature controller 1120 is intended for mobile use and the energy supply via batteries 1140 is limited.

The pressure sensor 1127 is preferably positioned to measure the air pressure in at least one of the pneumatic conduits and generate a pressure signal, and the control unit's microcontroller is operatively connected to the pressure sensor and configured to read the pressure signal of the pressure sensor, and when the air compressor 1124 is inflating the inflatable pouch 1123, if the pressure signal

indicates the pressure in the at least one pneumatic conduit reaches a first stored pressure setpoint the microcontroller terminates inflation of the inflatable pouch by the air compressor, and when the air outlet valve is deflating the inflatable pouch, if the pressure signal indicates a pressure in the at least one pneumatic conduit
5 reaches a second stored pressure setpoint the microcontroller terminates deflation of the inflatable pouch by the air outlet valve 1125.

Preferably, when the temperature measured by the temperature sensor 1129 exceeds a stored temperature setpoint, the control unit 1126 causes inflation of the inflatable member to the first inflation state to open the valve 1010, and when the
10 temperature measured by the temperature sensor is below the stored temperature setpoint, the control unit causes deflation of the inflatable member to the second inflation state to close the valve 1010.

The foregoing described embodiments depict different components contained within, or connected with, different other components. It is to be understood that
15 such depicted architectures are merely exemplary, and that in fact many other architectures can be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen
20 as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being "operably connected," or "operably coupled," to each other to achieve the desired functionality.

While particular embodiments of the present invention have been shown and
25 described, it will be obvious to those skilled in the art that, based upon the teachings herein, changes and modifications may be made without departing from this invention and its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of this invention. Furthermore, it is to be understood that the
30 invention is solely defined by the appended claims. It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should

be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding,

5 the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation,

10 even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled

15 in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, typically means at least two recitations, or two or more recitations).

Accordingly, the invention is not limited except as by the appended claims.

What is claimed is:

1. A sorption system, comprising:
 - an evaporator structured to contain a working fluid, and operable to evaporate the working fluid to produce a working fluid gas in the evaporator;
 - 5 a sorber structured to contain a sorption material to sorb the working fluid gas during a sorption phase;
 - a flow channel extending between the evaporator and the sorber to provide a gas pathway connecting the evaporator and the sorber;
 - a vapor control valve positioned to control the rate of vapor flow
 - 10 between the evaporator and the sorber through a flow channel, and being selectively operable to permit the flow of working fluid gas through the flow channel, to next stop the flow of working fluid gas through the flow channel, and after stopping the flow to then permit resumption of the flow of working fluid gas through the flow channel; and
 - a plunger operable to control the rate of vapor flow between the
 - 15 evaporator and the sorber through the flow channel; and
 - a vacuum barrier material positioned about the sorber, evaporator, and flow channel to provide a reduced pressure therewithin to promote evaporation of the working fluid at a reduced temperature compared to the temperature required at ambient pressure, the vacuum barrier material being a flexible material; and
 - 20 a temperature controller to adjust the position of the plunger to control the rate of vapor flow through the vapor control valve.
2. The sorption system of claim 1, wherein the vapor control valve has a contact surface and the temperature controller has a contact surface, the contact surface of the temperature controller being removably dockable to the contact
- 25 surface of the vapor control valve.
3. The sorption system of claim 1, where the vacuum barrier material includes first, second, and third flexible material portions, the third flexible material portion having a first end portion and a second end portion, the first end portion being in sealed engagement with the first flexible material portion and the second
- 30 end portion being in sealed engagement with the second flexible material portion to define an internal barrier, the third flexible material portion being positioned to create a stable sealing surface, the plunger protruding through the third flexible material portion, but not through the first flexible material portion or through the second

flexible material portion, the plunger being located proximal to the sealing surface, and the plunger being movable toward the sealing surface by atmospheric pressure.

4. The sorption system of claim 3, further including a temperature sensor positioned to measure the temperature of one of the evaporator surface and the air adjacent to the evaporator surface indicative of an evaporator surface temperature, and generate a temperature signal; and wherein the temperature controller includes:

an inflatable member having a first inflation state and a second inflation state; and

10 a control unit configured to evaluate the temperature signal and in response control the state of inflation of the inflatable member and thereby the operation of the valve to control the rate of gas flow between the evaporator and sorber through the gas pathway, when the inflatable member is in the first inflation state, the inflatable member causes opening of the valve to increase the rate of gas flow in the flow channel between the evaporator and the sorber through the gas pathway, and when the inflatable member is in the second inflation state, the inflatable member permits closing of the valve to reduce the rate of gas flow in the flow channel between the evaporator and the sorber through the gas pathway.

5. The sorption system of claim 1, further including a temperature sensor positioned to measure the temperature of one of the evaporator surface and the air adjacent to the evaporator surface indicative of an evaporator surface temperature, and generate a temperature signal; and wherein the temperature controller includes:

an inflatable member having a first inflation state and a second inflation state; and

30 a control unit configured to evaluate the temperature signal and in response control the state of inflation of the inflatable member and thereby the operation of the valve to control the rate of gas flow between the evaporator and sorber through the gas pathway, when the inflatable member is in the first inflation state, the inflatable member causes opening of the valve to increase the rate of gas flow in the flow channel between the evaporator and the sorber through the

gas pathway, and when the inflatable member is in the second inflation state, the inflatable member permits closing of the valve to reduce the rate of gas flow in the flow channel between the evaporator and the sorber through the gas pathway.

5 6. The sorption system of claim 5, wherein the temperature controller is removably dockable to the vapor control valve.

 7. The sorption system of claim 6, wherein the temperature controller includes a plurality of contact surfaces for removably docking the temperature controller to the vapor control valve.

10 8. The sorption system of claim 5, wherein the control unit includes a microcontroller operatively connected to the temperature sensor and configured to read the temperature signal of the temperature sensor, and if the temperature signal indicates an evaporator surface temperature above a stored temperature setpoint, the microcontroller changes the inflatable
15 member from the second inflation state to the first inflation state.

 9. The sorption system of claim 5, further including an air compressor, wherein the control unit includes a microcontroller operatively connected to the temperature sensor and the air compressor, the microcontroller configured to read the temperature signal of the temperature
20 sensor, and if the temperature signal indicates an evaporator surface temperature above a stored temperature setpoint, the microcontroller turns on the air compressor to inflate the inflatable member to change the inflation member from the second inflation state to the first inflation state.

 10. The sorption system of claim 9, wherein the microcontroller is
25 operatively connected to a memory, and the stored temperature setpoint is stored in the memory.

 11. The sorption system of claim 9, wherein the microcontroller is mounted on an electronic circuit board.

 12. The sorption system of claim 5, wherein the control unit
30 includes an electronic circuit operatively connected to the temperature sensor and configured to read the temperature signal of the temperature sensor, and if the temperature signal indicates an evaporator surface temperature above a stored temperature setpoint, the electronic circuit changes the inflatable member from the second inflation state to the first

inflation state.

13. The sorption system of claim 5, further including an air compressor, wherein the control unit includes an electronic circuit operatively connected to the temperature sensor and the air compressor, the electronic circuit configured to read the temperature signal of the temperature sensor, and if the temperature signal indicates an evaporator surface temperature above a stored temperature setpoint, the electronic circuit turns on the air compressor to inflate the inflatable member to change the inflation member from the second inflation state to the first inflation state.

14. The sorption system of claim 5, wherein the control unit compares the temperature measured by the temperature sensor with a stored temperature setpoint and inflates the inflatable member if the measured temperature is above the stored temperature setpoint.

15. The sorption system of claim 5, further including at least one battery for powering the temperature controller and a display, and wherein the control unit indicates the state of the at least one battery using the display.

16. The sorption system of claim 5, further including an electrical heating circuit, and wherein the control unit activates the electrical heating circuit when the temperature measured by the temperature sensor falls below a preselected temperature.

17. The sorption system of claim 5, further including a memory, and wherein the control unit stores in the memory the data measured by the temperature sensor during operation.

18. The sorption system of claim 5, further including a payload compartment, and wherein the control unit controls the state of inflation of the inflatable member to regulate the evaporation temperature in the evaporator to maintain the temperature measured by the temperature sensor at plus or minus 1 degree Kelvin of a preselected temperature.

19. The sorption system of claim 5, further including an air compressor, an air outlet valve and pneumatic conduits connecting the inflatable member with the air compressor for inflation of the inflatable member and with the air outlet valve for deflation of the inflatable member.

20. The sorption system of claim 19, wherein the air outlet valve is

configured to have a biasing force applied thereto biasing the valve toward a closed state, and the air outlet valve is movable to an open state to deflate the inflatable member, and when in the open state, at least a portion of the biasing force applied to the valve is transmitted to the inflatable member to
5 facilitate changing the inflatable member from the first inflation state to the second inflation state.

21. The sorption system of claim 19, wherein the air outlet valve is manually operable to manually exhaust air from the inflatable member.

22. The sorption system of claim 19, further including a pressure
10 sensor operatively connected to the control unit, the pressure sensor measuring the air pressure in at least one of the pneumatic conduits.

23. The sorption system of claim 22, wherein at least one of the air compressor and the air outlet valve is in operation until the pressure sensor measures a stored pressure setpoint.

24. The sorption system of claim 19, further including a pressure
15 sensor positioned to measure the air pressure in at least one of the pneumatic conduits and generate a pressure signal, and wherein the control unit includes a microcontroller operatively connected to the pressure sensor and configured to read the pressure signal of the pressure sensor, and when
20 the air compressor is inflating the inflatable member, if the pressure signal indicates the pressure in the at least one pneumatic conduit reaches a first stored pressure setpoint the microcontroller terminates inflation of the inflatable member by the air compressor, and when the air outlet valve is
deflating the inflatable member, if the pressure signal indicates a pressure in
25 the at least one pneumatic conduit reaches a second stored pressure setpoint the microcontroller terminates deflation of the inflatable member by the air outlet valve.

25. The sorption system of claim 5, further including a pressure
plate, and wherein the valve has a plunger which is movable to open the
30 valve, the pressure plate being located between the inflation member and the plunger, and when the inflation member is inflated to the first inflation state, the inflation member is in operable engagement with the pressure plate and applies a force through the pressure plate to the plunger sufficient to cause the plunger to open the valve.

26. The sorption system of claim 5 wherein the pressure plate is a rigid plate.

27. The sorption system of claim 5, wherein when the temperature measured by the temperature sensor exceeds a stored temperature setpoint, the control unit causes inflation of the inflatable member to the first inflation state to open the valve, and when the temperature measured by the temperature sensor is below the stored temperature setpoint, the control unit causes deflation of the inflatable member to the second inflation state to close the valve.

28. The sorption system of claim 27, wherein the control unit has a memory within which the stored temperature setpoint is stored.

29. The sorption system of claim 5, wherein when the temperature measured by the temperature sensor exceeds a first stored temperature setpoint, the control unit causes inflation of the inflatable member to the first inflation state to open the valve, and when the temperature measured by the temperature sensor is below a second stored temperature setpoint, the control unit causes deflation of the inflatable member to the second inflation state to close the valve.

30. The sorption system of claim 5, wherein the temperature sensor forms a portion of the temperature controller.

31. The sorption system of claim 5, wherein the temperature sensor does not form a portion of the temperature controller.

32. A sorption system for use with a temperature controller, comprising:

an evaporator structured to contain a working fluid, and operable to evaporate the working fluid to produce a working fluid gas in the evaporator;

a sorber structured to contain a sorption material to sorb the working fluid gas during a sorption phase;

a flow channel extending between the evaporator and the sorber to provide a gas pathway connecting the evaporator and the sorber;

a vapor control valve positioned to control the rate of vapor flow between the evaporator and the sorber through a flow channel, and being selectively operable to permit the flow of working fluid gas through the flow channel, to next stop the flow of working fluid gas through the flow channel,

and after stopping the flow to then permit resumption of the flow of working fluid gas through the flow channel; and

a plunger operable to control the rate of vapor flow between the evaporator and the sorber through the flow channel; and

5 a vacuum barrier material positioned about the sorber, evaporator, and flow channel to provide a reduced pressure therewithin to promote evaporation of the working fluid at a reduced temperature compared to the temperature required at ambient pressure, the vacuum barrier material being a flexible material; and

10 a contact surface removably dockable with the temperature controller to docket the temperature controller to the vapor control valve such that the position of the plunger may be adjusted by the temperature controller to control the rate of vapor flow through the vapor control valve.

33. The sorption system of claim 32, where the vacuum barrier
15 material includes first, second, and third flexible material portions, the third flexible material portion having a first end portion and a second end portion, the first end portion being in sealed engagement with the first flexible material portion and the second end portion being in sealed engagement with the second flexible material portion to define an internal barrier, the third
20 flexible material portion being positioned to create a stable sealing surface, the plunger protruding through the third flexible material portion, but not through the first flexible material portion or through the second flexible material portion, the plunger being located proximal to the sealing surface, and the plunger being movable toward the sealing surface by atmospheric
25 pressure.

34. A temperature controller for a sorption system having an evaporator containing a working fluid to evaporate the fluid to produce a gas, the evaporator including an evaporator surface, a sorber containing a sorption material to sorb the gas during a sorption phase, a flow channel
30 extending between the evaporator and the sorber to provide a gas pathway connecting the evaporator and sorber, a valve located within the flow channel and operable to control the rate of gas flow in the flow channel between the evaporator and the sorber through the gas pathway, and a temperature sensor positioned to measure the temperature of one of the evaporator

surface and the air adjacent to the evaporator surface indicative of an evaporator surface temperature, and generate a temperature signal, comprising:

- an inflatable member having a first inflation state and a second inflation state; and
- 5 a control unit configured to evaluate the temperature signal and in response control the state of inflation of the inflatable member and thereby the operation of the valve to control the rate of gas flow between the evaporator and sorber through the gas pathway, when the inflatable member is in the first inflation state, the inflatable member causes opening of the valve to increase the rate of gas flow in the flow channel between the evaporator and the sorber through the gas pathway, and when the inflatable member is in the second inflation state, the inflatable member permits closing of the valve to reduce the rate of gas flow in the flow channel between the evaporator and the sorber through the gas pathway.

35. The temperature controller of claim 34, further including a plurality of contact surfaces for removably docking the temperature controller to the valve.

- 36. The temperature controller of claim 34, wherein the control unit includes a microcontroller operatively connected to the temperature sensor and configured to read the temperature signal of the temperature sensor, and if the temperature signal indicates an evaporator surface temperature above a stored temperature setpoint, the microcontroller changes the inflatable member from the second inflation state to the first inflation state.

- 25 37. The temperature controller of claim 34, further including an air compressor, wherein the control unit includes a microcontroller operatively connected to the temperature sensor and the air compressor, the microcontroller configured to read the temperature signal of the temperature sensor, and if the temperature signal indicates an evaporator surface temperature above a stored temperature setpoint, the microcontroller turns on the air compressor to inflate the inflatable member to change the inflation member from the second inflation state to the first inflation state.

38. The temperature controller of claim 37, wherein the microcontroller is operatively connected to a memory, and the stored

temperature setpoint is stored in the memory.

39. The temperature controller of claim 37, wherein the microcontroller is mounted on an electronic circuit board.

40. The temperature controller of claim 34, wherein the control unit
5 includes an electronic circuit operatively connected to the temperature sensor and configured to read the temperature signal of the temperature sensor, and if the temperature signal indicates an evaporator surface temperature above a stored temperature setpoint, the electronic circuit changes the inflatable member from the second inflation state to the first
10 inflation state.

41. The temperature controller of claim 34, further including an air compressor, wherein the control unit includes an electronic circuit operatively connected to the temperature sensor and the air compressor, the electronic circuit configured to read the temperature signal of the temperature sensor,
15 and if the temperature signal indicates an evaporator surface temperature above a stored temperature setpoint, the electronic circuit turns on the air compressor to inflate the inflatable member to change the inflation member from the second inflation state to the first inflation state.

42. The temperature controller of claim 34, wherein the control unit
20 compares the temperature measured by the temperature sensor with a stored temperature setpoint and inflates the inflatable member if the measured temperature is above the stored temperature setpoint.

43. The temperature controller of claim 34, further including at least one battery for powering the control unit and a display, and wherein the
25 control unit indicates the state of the at least one battery using the display.

44. The temperature controller of claim 34 for a sorption system having an electrical heating circuit, wherein the control unit activates the electrical heating circuit when the temperature measured by the temperature sensor falls below a preselected temperature.

30 45. The temperature controller of claim 34, further including a memory, and wherein the control unit stores in the memory the data measured by the temperature sensor during operation.

46. The temperature controller of claim 34 for a sorption system having a payload compartment, wherein the control unit controls the state of

inflation of the inflatable member to regulate the evaporation temperature in the evaporator to maintain the temperature measured by the temperature sensor at plus or minus 1 degree Kelvin of a preselected temperature.

47. The temperature controller of claim 34, further including an air compressor, an air outlet valve and pneumatic conduits connecting the inflatable member with the air compressor for inflation of the inflatable member and with the air outlet valve for deflation of the inflatable member.

48. The temperature controller of claim 47, wherein the valve is configured to have a biasing force applied thereto biasing the valve toward a closed state, and the air outlet valve is movable to an open state to deflate the inflatable member, and when in the open state, at least a portion of the biasing force applied to the valve is transmitted to the inflatable member to facilitate changing the inflatable member from the first inflation state to the second inflation state.

49. The temperature controller of claim 47, wherein the air outlet valve is manually operable to manually exhaust air from the inflatable member.

50. The temperature controller of claim 47, further including a pressure sensor operatively connected to the control unit, the pressure sensor measuring the air pressure in at least one of the pneumatic conduits.

51. The temperature controller of claim 50, wherein at least one of the air compressor and the air outlet valve is in operation until the pressure sensor measures a stored pressure setpoint.

52. The temperature controller of claim 47, further including a pressure sensor positioned to measure the air pressure in at least one of the pneumatic conduits and generate a pressure signal, and wherein the control unit includes a microcontroller operatively connected to the pressure sensor and configured to read the pressure signal of the pressure sensor, and when the air compressor is inflating the inflatable member, if the pressure signal indicates the pressure in the at least one pneumatic conduit reaches a first stored pressure setpoint the microcontroller terminates inflation of the inflatable member by the air compressor, and when the air outlet valve is deflating the inflatable member, if the pressure signal indicates a pressure in the at least one pneumatic conduit reaches a second stored pressure

setpoint the microcontroller terminates deflation of the inflatable member by the air outlet valve.

53. The temperature controller of claim 34, further including a pressure plate, and wherein the valve has a plunger which is movable to
5 open the valve, the pressure plate being located between the inflation member and the plunger, and when the inflation member is inflated to the first inflation state, the inflation member is in operable engagement with the pressure plate and applies a force through the pressure plate to the plunger sufficient to cause the plunger to open the valve.

10 54. The temperature controller of claim 53, wherein the pressure plate is a rigid plate.

55. The temperature controller of claim 34, wherein when the temperature measured by the temperature sensor exceeds a stored temperature setpoint, the control unit causes inflation of the inflatable
15 member to the first inflation state to open the valve, and when the temperature measured by the temperature sensor is below the stored temperature setpoint, the control unit causes deflation of the inflatable member to the second inflation state to close the valve.

56. The temperature controller of claim 55, wherein the control unit
20 has a memory within which the stored temperature setpoint is stored.

57. The temperature controller of claim 34, wherein when the temperature measured by the temperature sensor exceeds a first stored temperature setpoint, the control unit causes inflation of the inflatable member to the first inflation state to open the valve, and when the
25 temperature measured by the temperature sensor is below a second stored temperature setpoint, the control unit causes deflation of the inflatable member to the second inflation state to close the valve.

58. The temperature controller of claim 34, wherein when the temperature measured by the temperature sensor exceeds a first stored
30 temperature setpoint, the control unit causes inflation of the inflatable member to the first inflation state to open the valve, and when the temperature measured by the temperature sensor is below a second stored temperature setpoint, the control unit causes deflation of the inflatable member to the second inflation state to close the valve.