

GAS COMPOSITION CONTROL SYSTEM WITHIN A STORAGE DEVICE

Field of the Invention

Engineering relates to the gas composition control system within a storage device

Background of the Invention

5 In transporting or storing perishable raw materials such as seeds, grains, food, or any agricultural products, managing the conditions inside the packaging or storing area is one of the key processes, which helps extend the shelf life of raw materials and prevent losses caused by other factors such as insects, fungi, or microorganisms. The commonly used methods to reduce such risk factors include thermal sterilization, which is suitable for creating sterile conditions for
10 raw materials that do not deteriorate when exposed to heat or for preparing packaging before storing such raw materials; temperature control within storage facilities to prevent the growth of living organisms such as insects or microorganisms; or the use of chemical agents toxic to living organisms for spraying or coating such raw materials during storage. The chemicals commonly used for coating or fumigating agricultural products to prevent insects include phosphine and
15 methyl bromide which are highly toxic and can easily decompose, resulting in minimal residue levels of these substances in perishable raw materials, making them safe for consumption.

Because the ease of decomposition of such chemicals, it is necessary to regularly coat or fumigate perishable raw materials with these substances to ensure that living organisms that may damage the perishable materials cannot grow or survive. This method, however, can lead to
20 fumigant resistance, resulting in the need to continually increase the concentration of chemicals used in fumigation.

Currently, alternative methods have been developed to control the conditions inside storing areas or packaging to create an environment unsuitable for the growth of insects, fungi, or microorganisms that may damage such perishable raw materials. For example, storing
25 perishable raw materials under specific temperature conditions. However, this method still has limitations due to the wide range of temperatures at which insects, fungi, or microorganisms is possibly grow. Additionally, excessively low temperatures may damage the structure of certain raw materials, leading to quality degradation. For instance, the deterioration of the starch structure in perishable raw materials can result in changes in texture and taste.

30 In addition to temperature control, a review of patent databases has revealed patents related to the storage of perishable raw materials that involve controlling the environment within the storage area to extend the shelf life of such raw materials, including:

Thai invention patent application number. 2201001372, titled “Storage Component Kits for Storing Perishable Objects,” has describes a packing box and the assembly of such a box for use in storing perishable raw materials. The packing box comprises a base that modified for lifting with a platform lifter to place the perishable raw materials on top, and a cover consisting of top and side walls are sized to enclose and surround the perishable objects on the base. The box also includes a sealing component to prevent air leakage into the packing box.

Chinese patent publication number. CN110482499 A, titled “Special Nitrogen-Oxygen Separator for Vacuum Nitrogen-Charging Insect-Killing Sterilization Equipment,” has describes a nitrogen and oxygen separator for supplying nitrogen to eliminate insects. It consists of a nitrogen and oxygen separation tank, which internally includes an oxygen separation tank and a carbon molecular sieve. The carbon molecular sieve packing contains carbon molecular particles. Air is compressed by an air compressor into the nitrogen and oxygen separation tank through an air intake pipe. The pressure is maintained for one minute to allow the carbon molecular sieve to fully absorb the oxygen gas. Subsequently, the control system commands the opening of an electromagnetic valve on the nitrogen discharge pipe, allowing nitrogen to enter the nitrogen storage tank. Afterward, the valve is closed, and the valve on the nitrogen and oxygen separation tank is opened to reduce the tank pressure, causing the oxygen gas adsorbed on the carbon molecular sieve to be released. Then, the control system commands the opening of the electromagnetic valve on the oxygen discharge pipe to allow oxygen to enter the oxygen storage tank, completing the nitrogen and oxygen separation process.

Chinese patent publication number. CN115735868 A, titled “Insect Killing System for Stored Tobacco Leaves and Storage Method,” has describes an insect controlling system for storing tobacco leaves, which are stored in warehouses in the form of tobacco leaf piles. The insect control system comprises a nitrogen production unit, a control unit, a detection unit, and an adjustment unit. The detection unit is connected to the control unit to monitor variables related to the environment inside the tobacco leaf pile. The control unit is connected to the adjustment unit to modify the conditions inside the tobacco leaf pile according to temperature and humidity. The storage of tobacco leaves includes the sealing step, then the nitrogen filling step to reduce the oxygen concentration within the tobacco leaf pile to below a predefined threshold. Then the storage step comprises that the control unit monitors the conditions inside the tobacco leaf pile and commands the adjustment unit to ensure the internal conditions meet the predefined criteria.

In the first patent, it mentions a packing box designed to prevent air leakage into the box but does not include a system for controlling the conditions inside the packing box. In contrast,

the Chinese patents publication number. CN110482499A and CN115735868A, disclosed the systems for controlling conditions inside storage areas, such as humidity and temperature, combined with the use of nitrogen gas to prevent insect growth or eliminate insects in enclosed spaces.

5 There is no mention of controlling the conditions or gas composition within the enclosed storing area, combining with the monitoring to detect abnormalities, such as air leakage or the rate of humidity increase, which could affect the deterioration of perishable raw materials. Additionally, there is no mention of utilizing a condition control system in combination with sealed storage devices or packaging to prevent exposure to external air and moisture, such as airtight
10 boxes or hermetic bags. In contrast, this invention discloses the development of a system for controlling conditions within storage areas, with the capability of monitoring or inspecting the conditions within these areas. The storage devices or packaging are designed to be sealed, allowing for timely tracking and resolving of errors in cases where the storage device or sealed packaging is damaged or if errors occur during the packaging of any raw materials.

15 **Summary of the Invention**

 The gas composition control system within a storage device, as described in this invention, comprises a storage device connected to an air control unit which includes at least a monitoring unit comprises a composition sensor, an air pressure sensor, and a control unit connected to the monitoring unit to analyze the conditions inside the storage device. The control unit is also
20 connected to a quality improvement unit, which includes at least a nitrogen gas generator and a vacuum pump to adjust the internal conditions of the storage device according to predefined criteria. Additionally, the control unit is networked with a personal communication device to notify users of changes in pressure, gas composition, or the conditions within the storage device. Users can also control or determine the criteria for adjusting the internal conditions of the storage device
25 using the personal communication device that is connected to the control unit via the network.

 The objective of this invention is to design a gas composition control system within a storage device to control the internal conditions of the storage device and monitor any changes occurring within it. This enables the timely tracking and resolving of errors in cases where the storage device or sealed packaging is damaged, or when errors occur during the packaging of any
30 raw materials.

Brief Description of the Drawings

Figure 1 illustrates one embodiment of the storage device.

Figure 2 illustrates one embodiment of the interaction under the gas composition control system within the storage device.

5 Detailed Description of the Invention

The gas composition control system within a storage device, as described in this invention, presents only one embodiment of the gas composition control system within a storage device. It is designed to enhance the efficiency of tracking and monitoring the internal conditions of a storage device for perishable raw materials. Additionally, it ensures that the internal conditions of the storage device meet predefined criteria.

The gas composition control system within a storage device comprises at least one storage device (100) connected to an air control unit (200). The storage device (100) is configured as a bag or container with any one or more of an airtight seal, gastight seal, watertight seal, or in combination thereof these sealing methods.

15 The most preferable storage device (100) includes at least an airtight seal.

Figure 1 illustrates one embodiment of the storage device (100), which comprises a first enclosure (101) and a second enclosure (102) that fit together perfectly to form an internal space for enclosing perishable raw materials. The first enclosure (101) and the second enclosure (102) are connected by a fastening mechanism (103), which can be selected from any one or more of zippers, snap locks, belts, locking cables, Velcro, or in combination thereof. The edges of the first enclosure (101) and the second enclosure (102) are further equipped with seals made from flexible polymers to prevent air leakage. The flexible polymers can be selected, but not limited to, from natural rubber, synthetic rubber, or plastic. The storage device (100) also includes a gas inlet (104) and a gas outlet (105), which are provided as ports for connecting pipes to supply gas into the storage device (100) or remove gas from the storage device (100) and a measurement port (106).

The most preferable storage device (100) is provided as a hermetic bag.

The first enclosure (101) and the second enclosure (102), in the most preferable configuration, are rectangular in shape while the gas inlet (104) and the measurement port (106) are not installed on the same plane.

30 The storage device (100) includes more than one gas inlet (104), with the most preferable configuration, comprises three gas inlets (104).

As shown in Figure 2, which illustrates one embodiment of the interaction under the gas composition control system, the storage device (100) is connected to the air control unit (200) via pipe which links to the gas inlet (104), gas outlet (105), and measurement port (106).

5 Additionally, the air control unit (200) is networked with a personal communication device (300), which is provided as a computing device such as a smartphone, tablet, or laptop. This enables users to modify the operational data of the air control unit (200) and access real-time information on the conditions within the storage area.

10 The air control unit (200) comprises at least a quality improvement unit (210) which is connected to the storage device (100) via a pipe which links to the gas inlet (104) and gas outlet (105). The quality improvement unit (210) includes at least a nitrogen gas production unit (211), provided as a nitrogen production system by a pressure swing adsorption process. This system comprises at least one adsorption tank that contains a porous adsorption material for absorbing oxygen gas, an air pump for compressing air from the external environment into the adsorption tank, vacuum pump to performs the desorption of gas from the adsorption material inside the
15 adsorption tank and at least one nitrogen gas storage tanks (2111) to store nitrogen gas filtered by the adsorption material inside the adsorption tank. The nitrogen gas storage tank (2111) is connected to the gas inlet (104) via a pipe for supplying nitrogen gas into the storage device (100).

The nitrogen gas storage tank (2111) is further equipped with a compressed air pump (2112) to increase the pressure of the nitrogen gas before supplying it to the storage device (100)
20 through the gas inlet (104) via a pipe.

The vacuum pump (212) is connected to the gas outlet (105) via a pipe to remove air from the storage device (100).

The pipes that connect the nitrogen gas storage tank (2111) to the gas inlet (104) or the vacuum pump (212) to the gas outlet (105) are further equipped with electric valves (203).

25 Additionally, the quality improvement unit (210) includes at least one fumigation gas storage tank (213) which is connected to the gas inlet (104) via a pipe. The fumigation gas storage tank (213) contains gases with properties to eliminate or inhibit the growth of microorganisms, fungi, or insects. These gases can be selected, but not limited to, from the group consisting of methyl bromide, phosphine, or ethylene oxide.

30 The pipe that connects the fumigation gas storage tank (213) to the gas inlet (104) is further equipped with an electric valve (203).

The fumigation gas storage tank (213) may further comprise a pressure pump to increase the gas pressure before supplying it to the storage device (100) through the gas inlet (104) via a pipe.

5 The measurement unit (220) is provided as a sensing device connected to the storage device (100) through a pipe via the measurement port (106) to monitor real-time internal conditions of the storage device. These conditions at least include oxygen concentration and gas pressure. The measurement unit (220) includes at least an oxygen concentration sensor and a gas pressure sensor and may further comprise any one or more of the following sensors: humidity sensor, temperature
10 concentration sensor, nitrogen concentration sensor, carbon dioxide concentration sensor, methyl bromide concentration sensor, phosphine concentration sensor, or ethylene oxide concentration sensor.

The measurement unit (220) is electrically connected to the control unit (230) to transmit real-time data on the internal conditions of the storage device to the control unit (230).

The control unit (230) is provided as an embedded system that is at least electrically connected to the quality improvement unit (210), the measurement unit (220), or the electric valve
15 (203) to processes data and issues commands for storage condition preparation processes and alerts.

The control unit (230) at least comprises a processor unit, user interface unit (231) provided as a combination of input devices and output devices to receive user commands and display real-time internal condition data of the storage device, and a memory unit (232) provided as a data
20 storage device.

The memory unit (232) is primarily provided to store optimal storage condition data, provided in the form of predefined criteria for comparison with real-time storage condition data which at least comprises an oxygen concentration range of 0.05 – 1 percent by volume.

The alert criteria data primarily comprise the monitoring period and predefined alert
25 criteria which are at least comprising the changes in any one or more of oxygen concentration, gas pressure, or in combination thereof.

The storage preparation data is provided in the form of predefined criteria for controlling and monitoring the storage preparation process, which at least includes an oxygen concentration of 0.01 – 2.00 percent by volume, gas pressure during the vacuum phase of -0.5 to 0 bar, the
30 duration of the nitrogen gas compression phase, the duration of the leak test phase, the duration of the vacuum phase, and the number of preparation cycles within the storage area.

Additionally, the memory unit (232) is provided to store data that can be read and executed by the control unit (230), which comprise at least:

5 The command data receiving unit (233) operable with the user interface unit (231) to receive command data from the user. These commands can be selected from any one or more of storage preparation commands, data request commands, or variable modification commands, in combination thereof. The unit then coordinates with other functional units to execute the received commands.

10 The command data receiving unit (233), that cooperates with the user interface unit (231), is further provided to receive a fumigation command from the user. The fumigation command at least comprises the type of gas, which can be selected from any one of the gases stored in the fumigation gas storage tank (213) or the nitrogen gas storage tank (2111); any one or more of the final concentration of the fumigation gas; the number of fumigation cycles; the duration of gas extraction; or the duration of fumigation, in combination thereof.

15 The fumigation command data is primarily predefined such that the final concentration of the fumigation gas is set at 20 to 250 parts per million (ppm), and the number of fumigation cycles is set at 3 cycles.

The data storage unit (234) which operates to receive real-time condition data from the storage device through the measurement unit (220) and stores this data in the memory unit (232).

20 The data storage unit (234) further processes variable modification command data, comprising the type of data to be modified which can be selected from one of optimal storage condition data, alert criteria data, or storage preparation data. It also includes the variable modification data, provided in the form of optimal storage condition data, alert criteria data, or storage preparation data that requires modification from the original data. The data storage unit (234) updates the relevant data stored in the memory unit (232) based on the received variable
25 modification command data.

The preparation unit (235) which operates to receive storage preparation command data from the command data receiving unit (233) and real-time condition data from the measurement unit (220) to compare this data with predefined criteria stored in the storage preparation data and then issues command the quality improvement unit (210) for executing the storage preparation
30 process. The preparation process is repeated for the number of cycles recorded in the storage preparation data.

The storage preparation process comprises the following steps:

a) Vacuum Phase: The preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) to remove air from the storage device (100) using the vacuum pump (212).

5 b) Leak Test Phase: The preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) to stop the vacuum process within the storage device (100) using the vacuum pump (212).

10 c) Nitrogen Gas Compression Phase: The preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) or the electric valve (203) to supply nitrogen gas into the storage device (100) through the nitrogen gas production unit (211).

15 The preparation unit (235) performs steps a. to c. as specified in the storage preparation data, which at least includes the following: oxygen concentration of 0.01 – 2.00 percent by volume, gas pressure during the vacuum phase of -0.5 to 0 bar, duration of the nitrogen gas compression phase, duration of the leak test phase, duration of the vacuum phase, and the number of preparation cycles within the storage area.

The most preferable storage preparation data specifies the following: the duration of the nitrogen gas compression phase is 7 minutes, the duration of the vacuum phase is 2 minutes, the duration of the leak test phase is 1 minute, and the number of preparation cycles within the storage area is 3 cycles.

20 Additionally, during steps a. to c., the preparation unit (235) is further compare real-time condition data from the storage device, as obtained from the measurement unit (220), with any one or more of the predefined criteria recorded in the storage preparation data or the preferable storage condition data to generate alerts in combination thereof, when the internal condition data of the storage device deviates from the predefined criteria. For example, this may occur when the
25 pressure during step a. or step b. leak test phase does not fall within the pressure range specified for the vacuum phase, as recorded in the storage preparation data.

30 After the storage preparation process, the preparation unit (235) may further perform operations by receiving fumigation commands from the command data receiving unit (233) and real-time condition data from the storage device via the measurement unit (220). The internal condition data of the storage device further comprises the concentration of the fumigation gas. This data is compared against the predefined criteria specified in the fumigation command then

issues commands to the quality improvement unit (210) to execute the fumigation process and repeats the fumigation process based on the information provided in the fumigation command.

The fumigation process comprises the following steps:

a. Gas Extraction Phase: The preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) to remove air from the storage device (100) using the vacuum pump (212).

b. Gas Compression Phase: The preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) or the electric valve (203) to supply gas into the storage device (100) from the fumigation gas storage tank (213).

The preparation unit (235) operates in fumigation process according to the data recorded in the fumigation command by repeating step a. and b. as specified in the fumigation command to ensure that the fumigation gas from the fumigation gas storage tank (213) thoroughly contacts the perishable raw materials inside the storage device (100).

During step b. of the fumigation process, the preparation unit (235) further receives real-time condition data from the storage device through the measurement unit (220), by comparing with the predefined final fumigation gas concentration criteria in the fumigation command. If the fumigation gas concentration falls within the predefined range, the preparation unit (235) transmits a command in the form of an electrical signal to the quality improvement unit (210) or the electric valve (203) to stop the supply of gas from the fumigation gas storage tank (213) into the storage device (100) for the duration specified in the fumigation command. This duration includes the fumigation time before proceeding to the next step.

The most preferable fumigation time is defined to be between 1 – 15 minutes.

After the fumigation process, the preparation unit (235) may further perform operations by instructing the quality improvement unit (210) to execute the storage preparation process and repeating the preparation cycles as recorded in the storage preparation data to ensure that the conditions within the storage area meet the one or a combination of criteria specified in the storage preparation data or the preferable storage condition data.

Additionally, the control unit (230) comprises a change monitoring unit (236) that receives real-time condition data from the storage device via the measurement unit (220), then compares this data with the preferable storage condition data or alert criteria data to generate real-time alerts for display to the user through the user interface unit (231).

The change monitoring unit (236) further operates to record the internal condition data of the storage device into the memory unit (232) for later retrieval, then calculates changes in variables measured by the measurement unit (220) and compares them with the alert criteria over a monitoring period. These criteria and monitoring periods are stored in the alert criteria data. The preferable monitoring period can be selected as 7 days or 15 days, and the alert criteria include at least an oxygen concentration of 0.01 – 5 percent by volume.

In one case, the alert criteria data includes at least the monitoring period and a fumigation gas concentration monitoring period, preferably between 15 – 60 minutes. This period is used to define the duration for monitoring the fumigation gas concentration in the storage device (100). The alert criteria include at least the oxygen concentration and fumigation gas concentration, as defined by the final fumigation gas concentration recorded in the fumigation command data. This data is received by the command data receiving unit (233) in cooperation with the user interface unit (231), which directs the preparation unit (235) to execute the fumigation process steps.

The change monitoring unit (236) generates real-time alerts if the condition data inside the storage device, as measured by the measurement unit (220), does not comply with the predefined criteria.

The display unit (237) receives display request commands from the command data receiving unit (233), retrieves the necessary data from the memory unit (232), and prepares it for display. The data is presented in the form of tables, graphs, charts, or electronic reports, which are shown to the user through the user interface unit (231).

The display unit (237) further operates to transmit display data to the external device communication unit (238) in cases where the display unit (237) receives a display request command that has been added by the personal communication device (300). This data is used for displaying to the user via the personal communication device (300).

The external device communication unit (238) operates to receive command data from the user, which is added via the personal communication device (300), and transmits this data to the command data receiving unit (233) to execute the respective commands and the external device communication unit (238) receives alert data or display data from the preparation unit (235), the change monitoring unit (236), or the display unit (237), then transmits it to the personal communication device (300) for display or notification to the user. This ensures that the user is informed of any abnormalities within the storage device (100), which may indicate signs of malfunction or deterioration within the system's functional units.

Any modifications or changes to this invention may be clearly understood and implemented by those skilled in the relevant art. The scope of this invention is determined by the nature of the invention as specified in the attached claims.

Best Mode of Invention

5 As Described in the Detailed Description of the Invention.

Claims

1. A gas composition control system within a storage device comprises at least one storage device (100) connected to an air control unit (200), which is networked with a personal communication device (300) provided as a computing device;

5 the storage device (100) includes a gas inlet (104), a gas outlet (105), and a measurement port (106) connected to the air control unit (200) via either a pipe, a pipe equipped with an electric valve (203), or a combination thereof;

 the air control unit (200) comprises at least a quality improvement unit (210), which includes a nitrogen gas production unit (211) provided as a nitrogen production system using
10 a pressure swing adsorption process, and a vacuum pump (212);

 a measurement unit (220) is provided as a sensing device connected to the storage device (100) via a pipe through the measurement port (106) to monitor real-time internal conditions of the storage device (100), comprising at least oxygen concentration and gas pressure;

 a control unit (230) is provided as an embedded system comprising at least a processor
15 unit, a user interface unit (231), and a memory unit (232), which is characterized in that:

 the quality improvement unit (210), the measurement unit (220), or the electric valve (203) is electrically connected to the control unit (230) to process data and execute commands for the storage preparation process and alerts, and that the control unit (230) comprises a memory unit (232) that records preferable storage condition data, alert criteria data, storage preparation data,
20 and operational unit data, including:

 a command data receiving unit (233) operable with the user interface unit (231) to receive user commands, which can be selected from any one or more of storage preparation commands, data request commands, or variable modification commands in combination thereof then coordinates with other operational units to execute these commands;

25 a data storage unit (234) that receives real-time condition data from the measurement unit (220) and stores it in the memory unit (232);

 a preparation unit (235) that receives storage preparation command data from the command data receiving unit (233) and real-time condition data from the measurement unit (220) for comparison with predefined criteria, then commands the quality improvement unit (210)
30 to execute the storage preparation process and repeats the process for the number of cycles recorded in the storage preparation data;

the storage preparation process comprises:

- a. a vacuum phase, wherein the preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) to remove air from the storage device (100) using the vacuum pump (212),
- 5 b. a leak test phase, wherein the preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) to stop the vacuum process within the storage device (100),
- 10 c. a nitrogen gas compression phase, wherein the preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) or the electric valve (203) to supply nitrogen gas into the storage device (100) through the nitrogen gas production unit (211);

the preparation unit (235) performs steps a. to c. according to the storage preparation data, which includes at least oxygen concentration at 0.01 – 2.00 percent by volume, gas pressure during the vacuum phase at -0.5 to 0 bar, duration of the nitrogen gas compression phase, duration of the leak test phase, duration of the vacuum phase, and the number of preparation cycles within the storage area,

a change monitoring unit (236) receives real-time condition data from the storage device (100) via the measurement unit (220) and compares it with the preferable storage condition data or alert criteria data to generate real-time alerts for display to the user via the user interface unit (231).

2. The gas composition control system within a storage device according to Claim 1, wherein the storage device (100) is provided as a bag or container with any one or more of an airtight seal, gastight seal, or watertight seal, in combination thereof these sealing methods.

3. The gas composition control system within a storage device according to Claim 1, wherein the storage device (100) comprises more than one gas inlet (104).

4. The gas composition control system within a storage device according to Claim 3, wherein the most preferable configuration of the storage device (100) comprises three gas inlets (104).

5. The gas composition control system within a storage device according to Claim 1, wherein the storage device (100) comprises a first enclosure (101) and a second enclosure (102) that fit together perfectly to form an internal space within the storage device (100).

6. The gas composition control system within a storage device according to Claim 5, wherein the first enclosure (101) and the second enclosure (102) are rectangular in shape, and the gas inlet (104) and the measurement port (106) are not installed on the same plane.

5 7. The gas composition control system within a storage device according to Claim 5, wherein the first enclosure (101) and the second enclosure (102) are connected by a fastening mechanism (103), which can be selected from any one or more of zippers, snap locks, belts, locking cables, Velcro, in combination thereof.

8. The gas composition control system within a storage device according to Claim 7, wherein the nitrogen gas storage tank (2111) and the gas inlet (104) are connected by a pipe that
10 comprises an electric valve (203) connected to the control unit (230).

9. The gas composition control system within a storage device according to Claim 1, wherein the most preferable configuration of the storage device (100) is a hermetic bag.

10. The gas composition control system within a storage device according to Claim 1, wherein the nitrogen gas production unit (211) stores the processed gas in at least one nitrogen gas
15 storage tank (2111), and the nitrogen gas storage tank (2111) is connected to the gas inlet (104) via a pipe for supplying nitrogen gas into the storage device (100).

11. The gas composition control system within a storage device according to Claim 1, wherein the vacuum pump (212) is connected to the gas outlet (105) via a pipe to remove air from the storage device (100).

20 12. The gas composition control system within a storage device according to Claim 10, wherein the vacuum pump (212) and the gas outlet (105) are connected by a pipe that comprises an electric valve (203) connected to the control unit (230).

13. The gas composition control system within a storage device according to Claim 1, wherein the measurement unit (220) comprises at least an oxygen concentration sensor and a gas
25 pressure sensor.

14. The gas composition control system within a storage device according to Claim 13, wherein the measurement unit (220) further comprises any one or more of the following sensors: a humidity sensor, a temperature sensor, a nitrogen concentration sensor, a carbon dioxide concentration sensor, a methyl bromide concentration sensor, a phosphine concentration sensor,
30 or an ethylene oxide concentration sensor, in combination thereof.

15. The gas composition control system within a storage device according to Claim 1, wherein the quality improvement unit (210) further comprises at least one fumigation gas storage tank (213) connected to the gas inlet (104) via a pipe.

5 16. The gas composition control system within a storage device according to Claim 15, wherein the fumigation gas storage tank (213) and the gas inlet (104) are connected by a pipe that comprises an electric valve (203).

10 17. The gas composition control system within a storage device according to Claim 15, wherein the fumigation gas storage tank (213) contains gas with properties to eliminate or inhibit the growth of microorganisms, fungi, or insects, which can be selected, but not limited to, from the group consisting of methyl bromide, phosphine, or ethylene oxide.

18. The gas composition control system within a storage device according to Claim 15 or Claim 16, wherein the command data receiving unit (233), cooperates with the user interface unit (231), is further configured to receive fumigation commands from the user, the fumigation commands comprises at least the type of gas, which can be selected from any one of the gases stored in the fumigation gas storage tank (213) or the nitrogen gas storage tank (2111); any one or more of the final concentration of the fumigation gas; the number of fumigation cycles; the duration of the vacuum phase; or the duration of fumigation, in combination thereof;

20 the preparation unit (235) is further configured to receive fumigation commands from the command data receiving unit (233) and real-time condition data from the storage device via the measurement unit (220), the internal condition data of the storage device is further comprising the concentration of the fumigation gas to compared against the predefined criteria specified in the fumigation command, then issues commands to the quality improvement unit (210) to execute the fumigation process and repeats the fumigation process based on the fumigation command data;

the fumigation process comprises:

- 25 a. a gas extraction phase, wherein the preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) or the electric valve (203) to remove air from the storage device (100) using the vacuum pump (212),
- 30 b. a gas compression phase, wherein the preparation unit (235) transmits command data in the form of electrical signals to the quality improvement unit (210) or the electric valve (203) to introduce gas into the storage device (100) from the fumigation gas storage tank (213),

the preparation unit (235) carries out the fumigation process based on the data recorded in the fumigation command, repeating steps a. and b. as specified in the fumigation command to ensure that the fumigation gas from the fumigation gas storage tank (213) thoroughly contacts the perishable raw materials inside the storage device (100).

5 19. The gas composition control system within a storage device according to Claim 17, wherein the preparation unit (235) further operates during step b. of the fumigation process by receiving real-time condition data from the storage device through the measurement unit (220) and comparing it with the predefined final fumigation gas concentration criteria in the fumigation command, when the fumigation gas concentration falls within the predefined range, the
10 preparation unit (235) sends a command in the form of electrical signals to the quality improvement unit (210) or the electric valve (203) to stop the supply of gas from the fumigation gas storage tank (213) into the storage device (100) for the duration specified in the fumigation command, which comprises the fumigation time.

 20. The gas composition control system within a storage device according to Claim 17,
15 wherein the preparation unit (235) further operates after the fumigation process by instructing the quality improvement unit (210) to execute the storage preparation process and repeating the preparation cycles as recorded in the storage preparation data.

 21. The gas composition control system within a storage device according to Claim 1, wherein the data storage unit (234) further operates to receive variable modification command
20 data, which comprising the type of data to be modified, selected from preferable storage condition data, alert criteria data, or storage preparation data, and the variable modification data, provided in the form of preferable storage condition data, alert criteria data, or storage preparation data that requires modification from the original data.

 22. The gas composition control system within a storage device according to Claim 1,
25 wherein the preparation unit (235) further operates during the storage preparation process, steps a. to c., by comparing real-time condition data from the storage device, as received from the measurement unit (220), with any one or more of predefined criteria recorded in the storage preparation data or the preferable storage condition data, in combination thereof.

 23. The gas composition control system within a storage device according to Claim 1,
30 wherein the preferable duration of the nitrogen gas compression phase is 7 minutes.

 24. The gas composition control system within a storage device according to Claim 1, wherein the preferable duration of the vacuum phase is 2 minutes.

25. The gas composition control system within a storage device according to Claim 1, wherein the preferable duration of the leak test phase is 1 minute.

26. The gas composition control system within a storage device according to Claim 1, wherein the preferable number of preparation cycles within the storage area is 3 cycles.

5 27. The gas composition control system within a storage device according to Claim 1, wherein the change monitoring unit (236) further operates to record internal condition data of the storage device (100) into the memory unit (232) for later retrieval and to calculate changes in variables measured by the measurement unit (220) and compared with the alert criteria data, which includes, at a minimum, the monitoring period and alert criteria.

10 28. The gas composition control system within a storage device according to Claim 1, wherein the alert criteria data comprises at least the monitoring period, the fumigation gas concentration monitoring period for determining the duration of monitoring the fumigation gas concentration within the storage device (100), and alert criteria, which comprises at least the oxygen concentration and the fumigation gas concentration.

15 29. The gas composition control system within a storage device according to Claim 1, wherein the control unit (230) comprises a display unit (237) that receives display request commands from the command data receiving unit (233), retrieves data from the memory unit (232), and prepares the display data in the form of tables, graphs, charts, or electronic reports.

20 30. The gas composition control system within a storage device according to Claim 1, wherein the control unit (230) comprises an external device communication unit (238) that receives command data from the user, which is added via the personal communication device (300), and transmits this data to the command data receiving unit (233).

25 31. The gas composition control system within a storage device according to Claim 30, wherein the external device communication unit (238) receives alert data or display data from the preparation unit (235), the change monitoring unit (236), or the display unit (237) and transmits it to the personal communication device (300).