A system for operating an HVAC system in the event of a thermostat failure is provided. The system includes the steps of activating a safety control program upon determining the thermostat failure has occurred, resetting a first timer, determining if an amount of time in the first timer exceeds a first time period, activating an HVAC system blower when the time remaining first timer exceeds the first time period, measuring a temperature of conditioned air with a temperature sensor, determining whether the temperature of conditioned air is less than a preset minimum temperature, activating an HVAC system heating unit if the conditioned air is less than the preset minimum temperature, determining whether the temperature of conditioned air is greater than a preset maximum temperature, activating an HVAC system cooling unit if the conditioned air is greater than the preset maximum temperature, and repeating the process.
FIG. 2A

1. Increase Timer 1 by First Time Increment 510.

2. Is Timer 1 > Variable 1? 512
   - YES: Go to A
   - NO: Go to 500

3. Determine if receiving valid communication data from thermostat? 502
   - YES: Activate backup control and turn off HVAC system 504
   - NO: Provide notification of thermostat failure 506

4. Reset Timer 1 (Air Sampling Cycle Timer) 508

A

D

E

F
FIG. 2C

B

Activate HVAC System

560

Reset Timer 3 (Heating Unit Minimum Operation Timer)

562

NO

Increase Timer 3 by Third Time Increment

564

Is Timer 3 ≥ Variable 6?

566

YES

Deactivate HVAC Heating Unit & Blower

574

NO

Is Temperature in Variable 3 ≥ Heating Temperature Set Point?

572

YES

Store Temperature in Variable 3

570

Determine Temperature at Sensor

568

NO

YES

E
HVAC AIR TEMPERATURE SAFETY SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 61/588,816, filed Jan. 20, 2012, the content of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to heating, ventilation, and air conditioning (HVAC) systems. More specifically, the present invention relates to a system and method for HVAC system operation in the event of an HVAC control system or thermostat failure.

BACKGROUND

[0003] Thermostats for an HVAC system are generally known in the art. A thermostat is a component of an HVAC system which can regulate the ambient temperature of an environment to be near a desired or targeted set point temperature. Generally, a thermostat will provide instructions to the HVAC system to provide heated and/or cooled air to the environment. The instructions are generally based upon targeting a desired set point temperature in the environment. For example, if the ambient temperature of an environment is below a desired or targeted set point temperature and the thermostat determines that the ambient temperature should be raised, the thermostat will signal to the HVAC system to provide heated air. As an additional example, if the ambient temperature of an environment is above a desired or targeted set point temperature and the thermostat determines that the ambient temperature should be lowered, the thermostat will signal to the HVAC system to provide cooled air.

[0004] However, known thermostats or control systems for an HVAC system have certain limitations. For example, in instances where a thermostat or control system fails or ceases to properly regulate the ambient temperature of an environment, the HVAC system will not receive further operational instructions from the thermostat or control system. This can result in unsafe conditions in the environment to be regulated by the HVAC system, such as extremely high temperatures (for example, in excess of 100°F) or extremely low temperatures (for example, below 40°F). The unsafe conditions caused by extreme temperatures can cause damage to the associated HVAC system. In addition, extreme temperatures can lead to damage to a home, building, or structure which houses the HVAC system. Such damage may include, but is not limited to, broken water pipes caused by freezing due to extreme low temperatures, or mold, mildew, or structural damage caused by high humidity due to extreme high temperatures.

[0005] For example, in a situation where the HVAC system was not operating at the time of thermostat failure, the result can be a prolonged amount of time where the HVAC system does not operate. During this prolonged time of HVAC system non-operation, the ambient temperature in the environment regulated by the HVAC system can increase or decrease based upon the ambient temperature outside of the environment regulated by the HVAC system, such as the temperature outdoors or outside. In times of higher outdoor temperatures, the ambient temperature in the environment regulated by the HVAC system can become very high (for example, in excess of 100°F). In times of lower outdoor temperatures, the ambient temperature in the environment regulated by the HVAC system can become very low (for example, below 40°F).

[0006] As another example, in a situation where the HVAC system was operating at the time of thermostat failure, the result can be a prolonged amount of time where the HVAC system does operate. This is known as a system "runaway" condition. During this prolonged time of HVAC system operation, the ambient temperature in the environment regulated by the HVAC system can continually increase or decrease. If the HVAC system is providing heated air, the ambient temperature in the environment regulated by the HVAC system can become very high (for example, in excess of 100°F). If the HVAC system is providing cooled air, the ambient temperature in the environment regulated by the HVAC system can become very low (for example, below 40°F).

SUMMARY OF THE DESCRIPTION

[0007] The present invention provides an HVAC air temperature safety control system which enables the HVAC system to continue to operate in situations of thermostat failure. The safety control system provides for HVAC operation in periods of predetermined low temperatures to prevent freezing of an environment regulated by the HVAC system due to thermostat or other HVAC control system failure. In addition, the safety control system provides for HVAC operation in periods of predetermined high temperatures to prevent overheating of an environment regulated by the HVAC system due to thermostat or other HVAC control system failure.

[0008] A system for operating an HVAC system is provided. The system includes determining whether a failure of a thermostat in operable communication with an HVAC system has occurred, activating a safety control program upon determining the thermostat failure has occurred, wherein the safety control program resides on electronically readable storage medium in operable communication with the HVAC system, resetting a first timer, determining if an amount of time in the first timer exceeds a first time period, increasing the amount of time remaining in the first timer by a first time increment if the amount of time remaining in the first timer does not exceed the first time period, activating an HVAC system blower when the time remaining first timer exceeds the first time period, measuring a temperature of conditioned air on a temperature sensor, wherein the temperature sensor is in communication with the safety control program and is not associated with the failed thermostat, determining whether the temperature of conditioned air is less than a preset minimum temperature, activating an HVAC system heating unit if the conditioned air is less than the preset minimum temperature, operating the heating unit until the conditioned air is greater than a heating temperature set point, determining, if the conditioned air is not less than the preset minimum temperature, whether the temperature of conditioned air is greater than a preset maximum temperature, activating an HVAC system cooling unit if the conditioned air is greater than the preset maximum temperature, operating the cooling unit until the conditioned air is less than a cooling temperature set point, and returning, if the temperature of conditioned air is not greater than the preset maximum temperature, to the step of resetting the first timer.

[0009] In addition, a system for operating an HVAC system upon a thermostat failure is provided. The system includes the steps of activating an HVAC safety control program, resetting a first timer, determining if an amount of time in the first timer...
exceeds a preset length of time between air sampling cycles, increasing the amount of time remaining in the first timer by a first time increment if the amount of time remaining in the first timer does not exceed the preset length of time between air sampling cycles, activating an HVAC system blower when the time remaining first timer exceeds the preset length of time between air sampling cycles, measuring a temperature of conditioned air on a temperature sensor, wherein the temperature sensor is in communication with the HVAC safety control program, determining whether the temperature of conditioned air is less than a low temperature limit set point, activating an HVAC system heating unit if the conditioned air is less than the low temperature limit set point, operating the heating unit until the conditioned air is greater than a target heating temperature set point, determining, if the conditioned air is not less than the low temperature limit set point, whether the temperature of conditioned air is greater than a high temperature limit set point, activating an HVAC system cooling unit if the conditioned air is greater than the high temperature limit set point, operating the cooling unit until the conditioned air is less than a target cooling temperature set point, and returning, if the temperature of conditioned air is not greater than the high temperature limit set point, to the step of resetting the first timer.

It should also be appreciated that an “HVAC system” may include a ducted system, an unducted system, or any other suitable system for providing conditioned air. For example, an HVAC system may include, but is not limited to, forced air system, an electrical base board heat system, hydronic heating or cooling, a window heat or air conditioning unit, or a free standing heating or air conditioning unit. In addition, it should be appreciated that “conditioned air” may include any suitable treatment or adjustment to air. For example, conditioned air may include, but is not limited to, heated air, cooled air, cleaned air, humidified air, dehumidified air, and/or filtered air. A “conditioning unit” may include any device or equipment which conditions air. For example, a conditioning unit may include, but is not limited to, a heat unit, an air cooling unit, a humidifier, a dehumidifier, an air filter, and/or any other device which may improve or enhance indoor air quality (“IAQ”).

It should also be appreciated that a “thermostat” may include any device, controller, or control system which regulates the temperature of an environment associated with an HVAC system and/or provides instructions for or signals operation of the HVAC system. In addition a “thermostat failure” may include any mechanical failure, electrical failure, or any other event in which the thermostat, device, controller, or control system ceases to properly operate and/or ceases to properly communicate with the HVAC system. For example, a “thermostat failure” may include, but is not limited to, a loss of power to the thermostat, a loss of the ability for the thermostat to measure temperature, a loss of the ability for the thermostat to accurately measure temperature, and/or a failure of the thermostat to interpret or understand temperature measurements.

Referring now to the Figures, FIG. 1 illustrates an example of an HVAC system 100 which may incorporate one or more examples of embodiments of a safety control system 500 for the operation of the HVAC system 100 upon thermostat failure. HVAC system 100 may include a return duct 110 coupled to a blower 130. A conditioning unit 120 may be coupled to return duct 110 and be provided between return duct 110 and blower 130. For example, as shown in FIG. 1, HVAC system 100 may include an air cleaning unit 120. In one or more examples of embodiments, the conditioning unit may include any suitable device adapted to condition air, including, but not limited to, an air filter, an air purifier, a humidifier, a dehumidifier, or any other known or future developed air cleaning, filtering, purification and/or conditioning device. In one or more examples of embodiments, the conditioning unit may be provided at any suitable or desired location in association with the return duct and/or supply duct. Further, in one or more examples of embodiments, a plurality of conditioning units may be provided at any suitable or desired locations in association with the HVAC system.

Blower 130 may also be coupled to a heating unit 140 and/or a cooling unit 150. Heating unit 140 and/or cooling unit 150 may subsequently be coupled to a supply duct 160. The supply duct 160 generally provides handled and/or conditioned air to the environment regulated by HVAC system 100. It should be appreciated that handled air may include, but not be limited to, air provided for ventilation, cleaned air, or filtered air. It should also be appreciated that conditioned air may include, but not be limited to, air which is heated and/or air which is cooled.
HVAC system 100 may also include a thermostat or user interface 200 and associated control system. Thermostat 200 may be provided in the environment regulated by HVAC system 100. Thermostat 200 generally monitors the temperature conditions in the environment, may provide information regarding the HVAC system 100 to user 400, may receive HVAC system 100 control settings entered by user 400, may store control settings for HVAC system 100, and/or may execute control settings for HVAC system 100.

Thermostat 200 may be in communication with an HVAC controller or equipment interface module or EIM 300. For example, thermostat 200 may include a blower call line 230, a heating unit call line 240, and/or a cooling unit call line 250. The blower call line 230, heating unit call line 240, and/or cooling unit call line 250 may couple thermostat 200 with HVAC controller 300. In addition, HVAC controller 300 may be provided near the air handling equipment 130, 140, 150. Further, HVAC controller 300 may be in communication with the air handling equipment 130, 140, 150. HVAC controller 300 may include a blower control line 330, a heating unit control line 340, and a cooling unit control line 350. The blower control line 330, heating unit control line 340, and cooling unit control line 350 may couple HVAC controller 300 with the respective blower 130, heating unit 140, and cooling unit 150. In one or more examples of embodiments, the blower call line, heating unit call line, cooling unit call line, blower control line, heating unit control line, and/or cooling unit control line may be any suitable communication medium to convey communication signals, including, but not limited to, wired, wireless, or any future developed suitable communication medium.

A temperature sensor or return air temperature sensor 360 may be in communication with HVAC controller 300 by a temperature sensor line 370. As illustrated in FIG. 1, temperature sensor 360 may be provided in return duct 110. Temperature sensor 360 may measure or detect the temperature of air within or traveling though return duct 110. Information gathered by temperature sensor 360 may be communicated to HVAC controller 300 through temperature sensor line 370. The information gathered may include, but is not limited to, the temperature of the measured air, a resistance, and/or a voltage. In one or more examples of embodiments, the temperature sensor may be any suitable device for measuring temperature, including, but not limited to, a thermistor, a resistance temperature detector, and/or a thermocouple temperature measurement sensor. In addition, in one or more examples of embodiments, the temperature sensor may be provided in any desired or suitable location for measuring the temperature of air, including, but not limited to, the environment regulated by the HVAC system, the supply duct, or any location suitable to measure the temperature of conditioned air selected by an HVAC system installer. Further, in one or more examples of embodiments, the temperature sensor may be associated with or housed in the thermostat. In one or more examples of embodiments, the temperature sensor line may be any suitable communication medium to convey communication signals, including, but not limited to, wired, wireless, or any future developed suitable communication medium.

In operation and use of HVAC system 100, a blower activation signal will be provided to blower 130 through blower control line 330. The signal may originate from thermostat 200 and be carried to HVAC controller 300 by blower call line 230, or may originate from HVAC controller 300.

Blower 130 will activate and pull return air through return duct 110. Return duct 110 provides air to be handled and/or conditioned by HVAC system 100. Return duct 110 is in communication with an air source, for example, but not limited to, air from the environment regulated by HVAC system 100 and/or air from an outside environment, such as from the outdoors. Generally, blower 130 pulls air into return duct 110 and subsequently through air cleaning unit 120. Blower 130 may then send the air through heating unit 140 and/or cooling unit 150, and into supply duct 160. The air is then pushed or blown by blower 130 through supply duct 160 and into the environment regulated by HVAC system 100. HVAC system 100 will continue to handle air until blower 130 is signaled to deactivate. These steps provide an example of handling or cycling air about the environment regulated by HVAC system 100.

HVAC system 100 may also warm or heat the air of the environment regulated by HVAC system 100. In addition to the steps recited above, a heating unit activation signal may be provided to heating unit 140 through heating unit control line 340. The signal may originate from thermostat 200. For example, thermostat 200 may measure the ambient temperature of an environment controlled by HVAC system 100 and determine that the environment temperature is below a predefined temperature limit, and thus too cold. Thermostat 200 will send a heating unit activation call to HVAC control 300 through heating unit call line 240. HVAC control 300 will subsequently transmit an associated heating unit activation signal to heating unit 140 through heating unit control line 340. Heating unit 140 will activate, increasing the temperature or warming the air pushed through heating unit 140 by blower 130. The warmer air will then be distributed into the environment regulated by HVAC system 100 via supply duct 160. HVAC system 100 will continue to warm or heat air until heating unit 140 is signaled to deactivate. In one or more examples of embodiments, the heating unit activation signal may originate from HVAC control 300 and be communicated to heating unit 140 through heating unit control line 340.

HVAC system 100 may also chill or cool the air of the environment regulated by HVAC system 100, in addition to the steps recited above in association with handling or cycling air, a cooling unit activation signal may be provided to cooling unit 150 through cooling unit control line 350. The signal may originate from thermostat 200. For example, thermostat 200 may measure the ambient temperature of an environment controlled by HVAC system 100 and determine that the environment temperature is above a pre-defined temperature limit, and thus too warm. Thermostat 200 will send a cooling unit activation call to HVAC control 300 through cooling unit call line 250. HVAC control 300 will subsequently transmit an associated cooling unit activation signal to cooling unit 150 through cooling unit control line 350. Cooling unit 150 will activate, decreasing the temperature or cooling the air pushed through cooling unit 150 by blower 130. The cooler air will then be distributed into the environment regulated by HVAC system 100 via supply duct 160. HVAC system 100 will continue to chill or cool air until cooling unit 150 is signaled to deactivate. In one or more examples of embodiments, the cooling unit activation signal may originate from HVAC control 300 and be communicated to cooling unit 150 through cooling unit control line 350.

The foregoing presents one or more examples of embodiments of HVAC system 100. HVAC system 100 may also include one or more embodiments of an HVAC safety.
control system or program or application 500. Safety control application 500 may continue to operate HVAC system 100 in situations of thermostat failure. HVAC safety control program 500 may be provided on a machine-readable or computer-readable medium or electronically readable storage medium which is in operable communication with HVAC system 100 and/or HVAC controller 300. In addition, HVAC safety control program 500 may reside as a program module which may be stored and/or operated on HVAC controller 300. The HVAC safety control program 500 may be prepared or written in any suitable programming language which enables communication with and/or control of HVAC system 100. The steps recited in association with HVAC safety control program 500 may reside or be stored as one or more instructions or program parameters which may be executable by HVAC system 100 and/or HVAC controller 300. In one or more examples of embodiments, HVAC safety control program 500 may reside on thermostat 200, for example on a multi-part thermostat with each part having an independent power source. In addition, in one or more examples of embodiments, HVAC safety control program 500 may reside on a controller which is independent from, but integrated into thermostat 200, for example as an add on component having an independent power source from thermostat 200. In one or more examples of embodiments, HVAC safety control program 500 may reside on an independent controller, device, or module which is independent and/or separate from thermostat 200. Such an independent controller, device, or module may be in communication with HVAC controller 300 and/or thermostat 200. In one or more examples of embodiments, the electronically readable storage medium may include any data storage device which can store data that can be thereafter read by an electronic or computer system. Examples of electronically readable storage medium may include, but is not limited to, a computer hard drive, read-only memory, CD-ROM, CD-R, CD-RW, DVD, DVD-RW, magnetic tapes, Universal Serial Bus (USB) flash drive, or any other suitable data storage device.

[0028] Referring to FIG. 2, the respective HVAC safety control program 500 includes a series of steps or processing instructions which are depicted in flow chart or flow diagram form. HVAC control program 500 may be implemented on a controller in association with HVAC system 100, for example, but not limited to, HVAC controller 300.

[0029] Referring to FIG. 2A, at step 502, HVAC safety control program 500 determines if controller 300 is receiving valid communication data from thermostat 200. For example, program 500 may initiate and send an electronic signal or control signal or signal to thermostat 200. As another example, program 500 may measure the air temperature through temperature sensor 360, and, if the air temperature is above a preset upper limit or below a preset lower limit, may attempt to signal thermostat 200. If at step 502, the determination is “yes,” controller 300 is receiving valid communication data from thermostat 200. If step 502 and continue to monitor and determine whether controller 300 is receiving valid communication data from thermostat 200. If the determination is “no,” controller 300 is not receiving valid communication data from thermostat 200, a thermostat failure has likely occurred. Program 500 will then move to step 504, in which backup control is activated.

[0030] At step 504, controller 300 turns off all relays, terminating the operation of blower 130, heating unit 140, and/or cooling unit 150. In addition, controller 300 deactivates all equipment status LED readouts, and activates backup control. [0031] Next, at step 506, program 500 may optionally provide notification outside of HVAC system 100 that a thermostat failure has occurred. For example, notification may include powering on a notification light at controller 300 and/or thermostat 200, initiating an audible alert signal, sending a notification of thermostat failure to a security service, sending a message providing notification of thermostat failure through email to one or more preprogrammed email addresses, sending a text message to one or more preprogrammed cellular telephone numbers providing notification of thermostat failure, and/or an making an automated telephone call to one or more preprogrammed telephone numbers that a thermostat failure has occurred. In addition, any of the notifications may also communicate that HVAC system backup control has been activated, it should be appreciated in one or more examples of embodiments that notification may be made through any suitable communication methodology.

[0032] At step 508, a timer, Timer 1, may be reset to an initial time period value. Timer 1 represents an air sampling cycle timer or return air sampling cycle timer. More specifically, Timer 1 may represent the measured length of time between air sampling cycles. Timer 1 may be used to ensure a preset or predetermined amount of time separates air sampling iterations. As illustrated in FIG. 2A, Timer 1 may be a “count-up” timer. Accordingly, Timer 1 may be reset to zero at step 508. In one or more examples of embodiments, Timer 1 may be a “count-down” timer which is reset to a predetermined amount of time at step 508.

[0033] At step 510, the current time period value stored or held in Timer 1 may be increased or incremented by a desired first time increment. A desired first time increment may be one second, thirty seconds, one minute, or any desired amount of second and/or minutes. In one or more examples of embodiments, Timer 1 may be decreased or decremented by a desired first time increment in association with a “count-down” timer.

[0034] Next, at step 512, program 500 determines if the current time period value stored in Timer 1, and which was previously adjusted or changed at step 510, is greater than a first predetermined air sampling cycle time period. If the current time period value stored in Timer 1 is greater than Variable 1, and which was previously adjusted or changed at step 510, program 500 will repeat step 502 and continue to monitor and determine whether controller 300 is receiving valid communication data from thermostat 200. If the determination is “no,” controller 300 is not receiving valid communication data from thermostat 200, a thermostat failure has likely occurred. Program 500 will then move to step 504, in which backup control is activated.

[0035] If the determination at step 512 is “no,” the current time period value stored in Timer 1 is not greater than Variable 1 (or in the alternative is not greater than or equal to, or not equal to Variable 1), program 500 returns to step 510. Steps 510 and 512 subsequently repeat until the determination at step 512 is “yes.” The current time period value stored in Timer 1 is greater than Variable 1 (or equal to, or greater than or equal to), control program 500 moves to step 514. In one or more examples of embodiments in association with a “count-down” timer, the “no” determination occurs when Timer 1 is greater than Variable 1, while
the "yes" determination occurs when Timer 1 is less than, less than or equal to, or equal to Variable 1.

[0036] Referring to FIG. 2B, at step 514, program 500 initiates an air sampling cycle. Specifically, at step 514, program 500 activates blower 130. For example, blower 130 may be activated through blower control line 330. As another example, program 500 may provide instructions to HVAC controller 300 to activate blower 130. Activation of blower 130 moves air through HVAC system 100, enabling temperature sensor 360 to accurately measure the temperature of air in the environment regulated by HVAC system 100.

[0037] Next, at step 516, a timer, Timer 2, may be reset to an initial time period value. Timer 2 represents an air sampling timer or return air sampling timer. More specifically, Timer 2 may represent the measured length of time blower 130 may operate before measuring the temperature of air in the environment regulated by HVAC system 100. Timer 2 may be used to ensure adequate air from the environment regulated by HVAC system 100 cycles through HVAC system 100. As illustrated in FIG. 2B, Timer 2 may be a "count-up" timer. Accordingly, Timer 2 may be reset to zero at step 516. In one or more examples of embodiments, Timer 2 may be a "count-down" timer which is reset to a predetermined amount of time at step 516.

[0038] At step 518, the current time period value stored or held in Timer 2 may be increased or incremented by a desired second time increment. A desired second time increment may be one second, thirty seconds, one minute, or any desired amount of second and/or minutes. In one or more examples of embodiments, Timer 2 may be decreased or decremented by a desired second time increment in association with a "count-down" timer.

[0039] Next, at step 520, a determination is made if the current time period value stored in Timer 2, and which was previously adjusted or changed at step 518, is greater than a second predetermined air sampling time period or second time period, Variable 2. This determination ascertains whether adequate time has elapsed to ensure adequate air from the environment regulated by HVAC system 100 cycles through HVAC system 100 before measuring the temperature of the air. It should be appreciated that Variable 2 may be a preset amount of time or a predetermined amount of time. In addition, the amount of time preset, entered, and/or stored as Variable 2 may be entered by the manufacturer, by an installer who installs the HVAC system 100 and/or program 500, or by a user 400. In one or more examples of embodiments, program 500 determines if Timer 2 is less than Variable 2 (or less than or equal to) in association with a "count-down" timer.

[0040] If the determination at step 520 is "no," the current time period value stored in Timer 2 is not greater than Variable 2 (or in the alternative is not greater than or equal to, or not equal to Variable 2), program 500 returns to step 518. Steps 518 and 520 subsequently repeat until the determination at step 520 is "yes." If the determination at step 520 is "yes," the current time value stored in Timer 2 is greater than Variable 2 (or equal to, or greater than or equal to), control program 500 moves to step 522. In one or more examples of embodiments in association with a "count-down" timer, the "no" determination occurs when Timer 2 is greater than Variable 2, while the "yes" determination occurs when Timer 2 is less than, less than or equal to, or equal to Variable 2.

[0041] At step 522, the ambient air temperature of the air from the environment regulated by HVAC system 100 is determined by measuring the temperature at temperature sensor 360. For example, in the embodiment illustrated in FIG. 1, the temperature of the air in return duct 110 is measured through temperature sensor 360. At step 523, the temperature measured at temperature sensor 360 may be stored as Variable 3.

[0042] At step 524, program 500 determines if the measured temperature stored in Variable 3 is less than or equal to a predetermined environment minimum temperature or minimum set point Variable 4. For example, the predetermined environment minimum temperature stored in Variable 4 may be 40° Fahrenheit. If the determination at step 524 is "yes," the temperature stored in Variable 3 is less than or equal to the predetermined temperature stored in Variable 4, program 500 moves to step 560. If the determination at step 524 is "no," the temperature stored in Variable 3 is not less than or equal to the predetermined temperature stored in Variable 4, program 500 moves to step 526. It should be appreciated that Variable 4 may be any desired or suitable preset temperature or predetermined temperature. In addition, the temperature preset, entered, and/or stored as Variable 4 may be entered by the manufacturer, by an installer who installs the HVAC system 100 and/or program 500, or by a user 400.

[0043] At step 526, program 500 determines if the measured temperature stored in Variable 3 is greater than or equal to a predetermined environment maximum temperature or maximum set point, Variable 5. For example, the predetermined environment maximum temperature stored in Variable 5 may be 100° Fahrenheit. If the determination at step 526 is "yes," the temperature stored in Variable 3 is greater than or equal the predetermined temperature stored in Variable 5, program 500 moves to step 570. If the determination at step 526 is "no," the temperature stored in Variable 3 is not greater than or equal to the predetermined temperature stored in Variable 5, program 500 moves to step 528. It should be appreciated that Variable 5 may be any desired or suitable preset temperature or predetermined temperature. In addition, the temperature preset, entered, and/or stored as Variable 5 may be entered by the manufacturer, by an installer who installs the HVAC system 100 and/or program 500, or by a user 400.

[0044] At step 528, HVAC blower 130 is deactivated. Program 500 then returns to step 508. Steps 508 through 528 will subsequently repeat until a determination of "yes" occurs at step 524, a determination of "yes" occurs at step 526, or HVAC controller 300 regains communication with thermostat 200. If HVAC controller 300 regains communication with thermostat 200 at any time, program 500 may terminate, as the thermostat failure will have ended. Upon termination of program 500, all HVAC system relays will be turned off, terminating the operation of blower 130, heating unit 140, and/or cooling unit 150. In addition, controller 300 deactivates all equipment status LED readouts and deactivates backup control program 500. Control of HVAC system 100 will subsequently be initiated and/or maintained by thermostat 200. In one or more examples of embodiments, to terminate program 500, HVAC system 100 may require some manual reset or manual actuation by an installer, user, or repair person in order for thermostat 200 to regain control of HVAC system 100.

[0045] Referring to FIG. 2C, at step 560, which is reached following a "yes" determination at step 524, the "heat" functionality of HVAC system 100 is activated. More specifically, heating unit 140 is activated. In various embodiments, heating unit 140 may be activated by instructions provided by
program 500. For example, program 500 may communicate with HVAC controller 300 to activate the “heat” of HVAC system 100. As such, HVAC controller 300 may send a signal across heater control line 340 to activate heating unit 140. However, in one or more examples of embodiments, any suitable methodology for activating the “heat” functionality of HVAC system 100 may be utilized or implemented.

[0046] Next at step 562, a timer, Timer 3, may be reset to an initial time period value. Timer 3 represents a heating unit minimum operation timer. More specifically, Timer 3 may represent the minimum length of time heating unit 140 may operate during a heating cycle operated by program 500. As illustrated in FIG. 2C, Timer 3 may be a “count-up” timer. Accordingly, Timer 3 may be reset to zero at step 562. In one or more examples of embodiments, Timer 3 may be a “count-up” timer which is reset to a predetermined amount of time at step 562. It should be appreciated that step 562 may coincide with step 560, or may occur immediately prior to or simultaneously with step 560 in order to insure the “heat” functionality of HVAC system 100 operates for the amount of time stored in Timer 3.

[0047] Next, at step 564, the current time period value stored or held in Timer 3 may be increased or incremented by a desired third time increment. A desired third time increment may be one second, thirty seconds, one minute, or any desired amount of second and/or minutes. In one or more examples of embodiments, Timer 3 may be decreased or decremented by a desired third time increment in association with a “count-down” timer.

[0048] Next, at step 566, a determination is made if the current time period value stored in Timer 3, and which was previously adjusted or changed at step 564, is greater than or equal to a predetermined heating equipment minimum on time or minimum run time or sixth time period, Variable 6. This determination ascertain whether adequate time has elapsed to ensure a minimum amount of heating for the environment regulated by HVAC system 100. In addition, the determination may ensure the HVAC system 100 heating unit 140 operates or runs for a minimum amount of time. It should be appreciated that Variable 6 may be a preset amount of time or a predetermined amount of time. In addition, the amount of time preset, entered, and/or stored as Variable 6 may be entered by the manufacturer, by an installer who installs the HVAC system 100 and/or program 500, or by a user 400. In one or more examples of embodiments, program 500 determines if Timer 3 is less than Variable 6 (or less than or equal to) in association with a “count-down” timer.

[0049] If the determination at step 566 is “no,” the current time period value stored in Timer 3 is not greater than Variable 6 (or in the alternative is not greater than or equal to, or not equal to Variable 6), program 500 returns to step 564. Steps 564 and 566 subsequently repeat until the determination at step 566 is “yes.” If the determination at step 566 is “yes,” the current time value stored in Timer 3 is greater than or equal to Variable 6 (or in various embodiments equal to, or greater than), control program 500 moves to step 568. In one or more examples of embodiments in association with a “count-down” timer, the “no” determination occurs when Timer 3 is greater than Variable 6, while the “yes” determination occurs when Timer 3 is less than, less than or equal to, or equal to Variable 6.

[0050] At step 568, the ambient air temperature of the air from the environment regulated by HVAC system 100 is determined by measuring the temperature at temperature sensor 360. For example, in the embodiment illustrated in FIG. 1, the temperature of the air in return duct 110 is measured through temperature sensor 360. At step 570, the temperature measured at temperature sensor 360 may be stored, for example again as Variable 3. In various embodiments, the temperature measured at temperature sensor 360 may be stored in a separate, unique variable, for example as Variable 10.

[0051] At step 572, a determination whether the measured temperature stored in Variable 3 is greater than or equal to a predetermined heating temperature set point or heating set point Variable 7. For example, the predetermined heating temperature set point stored in Variable 7 may be 43° Fahrenheit. If the determination at step 572 is “no,” the temperature stored in Variable 3 is not greater than or equal to the predetermined heating temperature set point stored in Variable 7, program 500 returns to step 568. Steps 568, 570, and 572 subsequently repeat and the HVAC system 100, blower 130 and heating unit 140 continue to operate until the determination at step 572 is “yes.” If the determination is “yes,” the temperature stored in Variable 3 is greater than or equal to the predetermined heating temperature set point stored in Variable 7, program 500 proceeds to step 574. It should be appreciated that Variable 7 may be any desired or suitable preset temperature or predetermined temperature. In addition, the temperature preset, entered, and/or stored as Variable 7 may be entered by the manufacturer, by an installer who installs the HVAC system 100 and/or program 500, or by a user 400.

[0052] At step 574, the blower 130 and heating unit 140 are deactivated. Next, program 500 will return to step 508. Steps 508 through 528 will subsequently repeat until a determination of “yes” occurs at step 524, a determination of “yes” occurs at step 526, or HVAC controller 300 regains communication with thermostat 200. If HVAC controller 300 regains communication with thermostat 200 at any time, program 500 may terminate, as the thermostat failure will have ended. Upon termination of program 500, all HVAC system relays will be turned off, terminating the operation of blower 130, heating unit 140, and/or cooling unit 150. In addition, controller 300 deactivates all equipment status LED readouts and deactivates backup control program 500. Control of HVAC system 100 will subsequently be initiated and/or maintained by thermostat 200. In one or more examples of embodiments, program 500 may require some manual reset or manual actuation by an installer, user, or repair person in order for thermostat 200 to regain control of HVAC system 100.

[0053] Referring to FIG. 2D, at step 580, which is reached following a “yes” determination at step 526, the “cooling” functionality of HVAC system 100 is activated. More specifically, cooling unit 150 is activated. In various embodiments, cooling unit 150 may be activated by instructions provided by program 500. For example, program 500 may communicate with HVAC controller 300 to activate the “cooling” of HVAC system 100. As such, HVAC controller 300 may send a signal across cooling control line 350 to activate cooling unit 150. However, in one or more examples of embodiments, any suitable methodology for activating the “cooling” functionality of HVAC system 100 may be utilized or implemented.

[0054] Next at step 582, a timer, Timer 4, may be reset to an initial time period value. Timer 4 represents a cooling unit minimum operation timer. More specifically, Timer 4 may represent the minimum length of time cooling unit 150 may operate during a cooling cycle operated by program 500. As
illustrated in FIG. 2D, Timer 4 may be a “count-up” timer. Accordingly, Timer 4 may be reset to zero at step 582. In one or more examples of embodiments, Timer 4 may be a “count-down” timer which is reset to a predetermined amount of time at step 582. It should be appreciated that step 582 may coincide with step 580, or may occur immediately prior to or simultaneously with step 580 in order to insure the “cooling” functionality of HVAC system 100 operates for the amount of time stored in Timer 4.

[0055] Next, at step 584, the current time period value stored or held in Timer 4 may be increased or incremented by a desired fourth time increment. A desired fourth time increment may be one second, thirty seconds, one minute, or any desired amount of second and/or minutes. In one or more examples of embodiments, Timer 4 may be decreased or decremented by a desired fourth time increment in association with a “count-down” timer.

[0056] Next, at step 586, a determination is made if the current time period value stored in Timer 4, and which was previously adjusted or changed at step 584, is greater than or equal to a predetermined cooling equipment minimum on time or minimum run time or eighth time period, Variable 8. This determination ascertain that adequate time has elapsed to ensure a minimum amount of cooling for the environment regulated by HVAC system 100. In addition, the determination may ensure the HVAC system 100 cooling unit 150 operates or runs for a minimum amount of time. It should be appreciated that Variable 8 may be a preset amount of time or a predetermined amount of time. In addition, the amount of time preset, entered, and/or stored as Variable 8 may be entered by the manufacturer, by an installer who installs the HVAC system 100 and/or program 500, or by a user 400. In one or more examples of embodiments, program 500 determines if Timer 4 is less than Variable 8 (or less than or equal to) in association with a “count-down” timer.

[0057] If the determination at step 586 is “no,” the current time period value stored in Timer 4 is not greater than Variable 8 (or in the alternative is not greater than or equal to, or not equal to Variable 8), program 500 returns to step 584. Steps 584 and 586 subsequently repeat until the determination at step 586 is “yes.” If the determination at step 586 is “yes,” the current time value stored in Timer 4 is greater than or equal to Variable 8 (or in various embodiments equal to, or greater than, control in Timer 500 moves to step 588. In one or more examples of embodiments in association with a “count-down” timer, the “no” determination occurs when Timer 4 is greater than Variable 8, while the “yes” determination occurs when Timer 4 is less than, less than or equal to, or equal to Variable 8.

[0058] At step 588, the ambient air temperature of the air from the environment regulated by HVAC system 100 is determined by measuring the temperature at temperature sensor 360. For example, in the embodiment illustrated in FIG. 1, the temperature of the air in return duct 110 is measured through temperature sensor 360. At step 590, the temperature measured at temperature sensor 360 may be stored, for example again as Variable 3. In various embodiments, the temperature measured at temperature sensor 360 may be stored in a separate, unique variable, for example as Variable 11.

[0059] At step 592, a determination whether the measured temperature stored in Variable 3 is less than or equal to a predetermined cooling temperature set point or cooling set point Variable 9. For example, the predetermined heating temperature set point stored in Variable 9 may be 97° Fahrenheit. If the determination at step 592 is “no,” the temperature stored in Variable 3 is not less than or equal to the predetermined cooling temperature set point stored in Variable 9, program 500 returns to step 588. Steps 588, 590, and 592 subsequently repeat and the HVAC system 100, blower 130 and cooling unit 150 continue to operate until the determination at step 592 is “yes.” If the determination is “yes,” the temperature stored in Variable 3 is less than or equal to the predetermined cooling temperature set point stored in Variable 9, program 500 proceeds to step 594. It should be appreciated that Variable 9 may be any desired or suitable preset temperature or predetermined temperature. In addition, the temperature preset, entered, and/or stored as Variable 9 may be entered by the manufacturer, by an installer who installs the HVAC system 100 and/or program 500, or by a user 400.

[0060] At step 594, the blower 130 and cooling unit 150 are deactivated. Next, program 500 will return to step 508. Steps 508 through 528 will subsequently repeat until a determination of “yes” occurs at step 524, a determination of “yes” occurs at step 526, or HVAC controller 300 regains communication with thermostat 200. If HVAC controller 300 regains communication with thermostat 200 at any time, program 500 may terminate, as the thermostat failure will have ended. Upon termination of program 500, all HVAC system relays will be turned off, terminating the operation of blower 130, heating unit 140, and/or cooling unit 150. In addition, controller 300 deactivates all equipment status LED readouts and deactivates backup control program 500. Control of HVAC system 100 will subsequently be initiated and/or maintained by thermostat 200. In one or more examples of embodiments, to terminate program 500, HVAC system 100 may require some manual reset or manual actuation by an installer, user, or repair person in order for thermostat 200 to regain control of HVAC system 100.

[0061] It should be appreciated that in one or more examples of embodiments of safety control program 500, the first time period (Variable 1), the second time period (Variable 2), predetermined environment minimum temperature (Variable 4), predetermined environment maximum temperature (Variable 5), minimum heating equipment on time (Variable 6), minimum cooling equipment on time (Variable 8), heating temperature set point (Variable 7), cooling temperature set point (Variable 9), and other timers or target temperatures may be any predetermined value which may be set by the manufacturer, user, or HVAC system installer. In addition, certain Variables may be preset or entered for certain desired operational parameters, for example to intentionally add some amount of hysteresis into the control program 500. Further, in one or more examples of embodiments of safety control program 500, program 500 and/or HVAC controller 300 may be implemented on a thermostat which may have separate and dedicated circuitry and power to enable operation of program 500 and/or controller 300 in the occurrence of a thermostat failure.

[0062] In operation and use of control program 500, an HVAC system 100 will typically be in communication with a thermostat 200. Thermostat 200 will provide operating instructions to HVAC system 100 and/or HVAC controller 300. Should thermostat 200 cease to properly operate or function, control program 500 will initiate and assume control of operation of HVAC system 100. Control program 500 will make a determination whether HVAC system 100 is receiving communication data or signals, valid communica-
tion data or signals, or any data or signals from thermostat 200 (at step 502 of FIG. 2A). If thermostat 200 is not properly functioning, backup control of HVAC system 100 will be activated and all HVAC system components will be deactivated or powered down (at step 504 of FIG. 2A). A notification of thermostat failure may also be initiated (at step 506 of FIG. 2A). An air sampling cycle timer is then reset (at step 508 of FIG. 2A). The air sampling cycle timer will then be initiated to track and store in Timer 1 the amount of time between cycles of air sampling (at steps 510-512 of FIG. 2A). When the elapsed amount of time between cycles of air sampling (Timer 1) exceeds a preset amount of time between air sampling cycles (Variable 1) (at step 512 of FIG. 2A), an air sampling cycle will be initiated (at steps 514-528 of FIG. 2B).

During an air sampling cycle, air may be cycled through the HVAC system 100 for a period of time. Specifically, HVAC blower 130 may be activated (at step 514 of FIG. 2B). Simultaneously, an air sampling timer is then reset (at step 516 of FIG. 2B). The air sampling timer will then be initiated to track and store in Timer 2 the amount of time of the air sampling cycle (at steps 518-520 of FIG. 2B). The air sampling timer allows for air to be blown through HVAC system 100 for a period of time (i.e. the amount of time elapsed in Timer 2). When the elapsed amount of time of the air sampling timer (Timer 2) exceeds a preset amount of time for an air sampling cycle (Variable 2) (at step 520 of FIG. 2B), the temperature of the air cycled through the HVAC system 100 will be measured and stored (in Variable 3) (at steps 522-523 of FIG. 2B). The stored temperature of the air cycled through the HVAC system 100 is then analyzed (at steps 524-526 of FIG. 2B). If the stored temperature (Variable 3) is below or equal to (or alternatively below) a low temperature limit set point (Variable 4), a heating cycle will be initiated (at step 524 of FIG. 2B). If the stored temperature (Variable 3) is not below or equal to (or alternatively not below) a low temperature limit set point (Variable 4), the stored temperature will be additionally analyzed (at step 526 of FIG. 2B). If the stored temperature (Variable 3) is above or equal to (or alternatively above) a high temperature limit set point (Variable 5), a cooling cycle will be initiated (at step 526 of FIG. 2B). If the stored temperature (Variable 3) is not above or equal to (or alternatively not above) a high temperature limit set point (Variable 5), the HVAC system blower is deactivated (at step 528 of FIG. 2B). The system will then initiate another time period between air sample cycles by resetting the air sampling cycle timer (Timer 1) (repeating steps 508-512 of FIG. 2A). After completion of another time period between air sample cycles (steps 508-512 of FIG. 2A), another air sampling cycle will be initiated (steps 514-528 of FIG. 2B). This process will repeat until a heating cycle is initiated (steps 560-574 of FIG. 2C), a cooling cycle is initiated (steps 580-594 of FIG. 2D), or the control program 500 terminates.

If a heating cycle is initiated (steps 560-574 of FIG. 2C), the heating unit 150 of HVAC system 100 is activated (at step 560 of FIG. 2C). Simultaneously, a heating unit minimum operation timer is reset (at step 562 of FIG. 2C). The heating unit minimum operation timer will then be initiated to track and store in Timer 3 the amount of time the heating unit operates (at steps 564, 566 of FIG. 2C). The heating unit minimum operation timer represents the minimum length of time heating unit 140 may operate during a heating cycle. When the elapsed amount of time of the heating unit minimum operation timer (Timer 3) exceeds (or is greater than or equal to) a preset heating unit minimum run time (Variable 6) (at step 566 of FIG. 2C), the temperature of the air cycled through the HVAC system 100 will be measured and stored (in Variable 3) (at steps 568, 570 of FIG. 2C). The stored temperature of the heated air cycled through the HVAC system 100 and environment is then analyzed (at step 572 of FIG. 2C). If the stored temperature (Variable 3) is not greater than or equal to (or alternatively not greater than) a heating temperature set point (Variable 7) (at step 572 of FIG. 2C), the heating cycle will continue and additional temperatures of the air will be taken and analyzed (repeat steps 568-572 of FIG. 2C). If the stored temperature (Variable 3) is greater than or equal to (or alternatively greater than) a heating temperature set point (Variable 7), the heating cycle will be terminated, with the heating unit 140 and HVAC blower 130 being deactivated (at step 574 of FIG. 2C). The system will then initiate another time period between air sample cycles by resetting the air sampling cycle timer (Timer 1) (repeating steps 508-512 of FIG. 2A). After completion of another time period between air sample cycles (steps 508-512 of FIG. 2A), another air sampling cycle will be initiated (steps 514-528 of FIG. 2B). This process will repeat until a heating cycle is initiated (steps 560-574 of FIG. 2C), a cooling cycle is initiated (steps 580-594 of FIG. 2D), or the control program 500 terminates.

If a cooling cycle is initiated (steps 580-594 of FIG. 2D), the cooling unit 150 of HVAC system 100 is activated (at step 580 of FIG. 2D). Simultaneously, a cooling unit minimum operation timer is reset (at step 582 of FIG. 2D). The cooling unit minimum operation timer will then be initiated to track and store in Timer 4 the amount of time the cooling unit operates (at steps 584, 586 of FIG. 2D). The cooling unit minimum operation timer represents the minimum length of time cooling unit 150 may operate during a cooling cycle. When the elapsed amount of time of the cooling unit minimum operation timer (Timer 4) exceeds (or is greater than or equal to) a preset cooling unit minimum run time (Variable 8) (at step 586 of FIG. 2D), the temperature of the air cycled through the HVAC system 100 will be measured and stored (in Variable 3) (at steps 588, 590 of FIG. 2D). The stored temperature of the cooled air cycled through the HVAC system 100 and environment is then analyzed (at step 592 of FIG. 2D). If the stored temperature (Variable 3) is not less than or equal to (or alternatively not less than) a cooling temperature set point (Variable 9) (at step 592 of FIG. 2D), the cooling cycle will continue and additional temperatures of the air will be taken and analyzed (repeat steps 588-592 of FIG. 2D). If the stored temperature (Variable 3) is less than or equal to (or alternatively less than) a cooling temperature set point (Variable 9), the cooling cycle will be terminated, with the cooling unit 150 and HVAC blower 130 being deactivated (at step 594 of FIG. 2D). The system will then initiate another time period between air sample cycles by resetting the air sampling cycle timer (Timer 1) (repeating steps 508-512 of FIG. 2A). After completion of another time period between air sample cycles (steps 508-512 of FIG. 2A), another air sampling cycle will be initiated (steps 514-528 of FIG. 2B). This process will repeat until a heating cycle is initiated (steps 560-574 of FIG. 2C), a cooling cycle is initiated (steps 580-594 of FIG. 2D), or the control program 500 terminates.

To further illustrate operation and use of control program 500, the following provides an example of certain operational scenarios using certain system conditions. The scenarios and associated system conditions are provided for example only, and are not meant to be limiting in any way.
Any number or combination of scenarios or system conditions may be realized in association with an HVAC system 100 and/or environment regulated by an HVAC system 100. As an example of a thermostat 200 failure scenario, the system may have the following hypothetical system conditions: all timers will be “count-up” timers, the first, second, third, and fourth time increments may all be 1 second (one second), the preset amount of time between air sampling cycles (Variable 1) may be 30 minutes (thirty minutes), the present amount of time for an air sampling cycle (Variable 2) may be 5 minutes (three minutes), the low temperature limit set point (Variable 4) may be 40° F. (forty degrees Fahrenheit), the high temperature limit set point (Variable 5) may be 100° F. (one hundred degrees Fahrenheit), the heating unit minimum run time (Variable 6) may be 2 minutes (two minutes), the heating temperature set point (Variable 7) may be 43° F. (forty-three degrees Fahrenheit), the cooling unit minimum run time (Variable 8) may be 2 minutes (two minutes), and the cooling temperature set point (Variable 9) may be 97° F. (ninety-seven degrees Fahrenheit). Control program 500 may begin by making a determination whether HVAC system 100 is receiving communication data or signals, valid communication data or signals, or any data or signals from thermostat 200 (at step 502 of FIG. 2A). If it is determined that thermostat 200 is not properly functioning, backup control of HVAC system 100 will be activated and all HVAC system components will be deacti

If it is determined that the temperature of the heated air cycled through the HVAC system 100 will be measured and stored (in Variable 3) at steps 504 of FIG. 2A. If the measured temperature (Variable 3) is not greater than or equal to (or alternatively not greater than) the heating temperature set point of 43° F. (43° F., or “Air Temperature is not ≥43°F.”), the heating cycle will be initiated (at step 520 of FIG. 2B). The system will then initiate another time period between air sample cycles (by repeating steps 508-512 of FIG. 2A). These processes will repeat until a heating cycle is initiated (steps 560-574 of FIG. 2C), a cooling cycle is initiated (steps 580-594 of FIG. 2D), or the control program 500 terminates.

If a cooling cycle is initiated (steps 560-574 of FIG. 2C), the heating unit 140 of HVAC system 100 is activated (at step 560 of FIG. 2C). Simultaneously, the heating unit minimum operation timer is reset to zero (at step 562 of FIG. 2C). The heating unit minimum operation timer will then be initiated, and Timer 3 will measure the elapsed amount of time of heating unit operation by adding one second to Timer 3 (at steps 564, 566 of FIG. 2C). If the stored temperature (Variable 3) is greater than or equal to (or alternatively not greater than) the heating temperature set point of 43° F. (forty-three degrees Fahrenheit), or “Air Temperature is not ≥43° F.” (at step 572 of FIG. 2C), the heating cycle will continue and additional temperatures of the air will be taken and analyzed (repeat steps 568-572 of FIG. 2C). If the stored temperature (Variable 3) is greater than or equal to (or alternatively greater than) the heating temperature set point of 43° F. (forty-three degrees Fahrenheit), or “Air Temperature is ≥43° F.” (at step 572 of FIG. 2C), the heating cycle will be terminated, with the heating unit 140 and HVAC blower 130 being deactivated (at step 574 of FIG. 2C). The system will then initiate another time period between air sample cycles (by repeating steps 508-512 of FIG. 2A). These processes will repeat until a heating cycle is initiated (steps 560-574 of FIG. 2C), a cooling cycle is initiated (steps 580-594 of FIG. 2D), or the control program 500 terminates.

If a cooling cycle is initiated (steps 580-594 of FIG. 2D), the cooling unit 150 of HVAC system 100 is activated (at step 580 of FIG. 2D). Simultaneously, a cooling unit minimum operation timer is reset to zero (at step 582 of FIG. 2D). The cooling unit minimum operation timer will then be initiated, and Timer 4 measure the elapsed amount of time of cooling unit operation by adding one second to Timer 4 (at steps 584, 586 of FIG. 2D). Timer 4 will continue to add one second until Timer 4 exceeds (or is greater than or equal to) the preset cooling unit minimum run time of two minutes, or “Timer 4 is ≥two minutes” (at step 586 of FIG. 2D). The temperature of the cooled air cycled through the HVAC system 100 will be measured and stored (in Variable 3) at steps 588, 590 of FIG. 2D), and analyzed (at step 592 of FIG. 2D). If the stored temperature (Variable 3) is not less than or equal to (or alternatively not less than) a cooling temperature set point of 97° F. (ninety-seven degrees Fahrenheit), or “Air Temperature is not ≤97°F.”, the measured air temperature will be additionally analyzed (at step 526 of FIG. 2B). If the measured air temperature (Variable 3) is above or equal to (or alternatively above) the high temperature limit set point of 100° F. (one hundred degrees Fahrenheit), or “Air Temperature is ≥100°F.”, a cooling cycle will be initiated (at step 526 of FIG. 2B). If the measured air temperature (Variable 3) is not above or equal to (or alternatively not above) a low temperature limit set point, or “Air Temperature is not ≥40°F.,” the HVAC system blower is deactivated (at step 528 of FIG. 2B). The system will then initiate another time period between air sample cycles (by repeating steps 508-512 of FIG. 2A). These processes will repeat until a heating cycle is initiated (steps 560-574 of FIG. 2C), a cooling cycle is initiated (steps 580-594 of FIG. 2D), or the control program 500 terminates.
Temperature is not \( \geq 97\degree F \) (at step 592 of FIG. 2D), the cooling cycle will continue and additional temperatures of the air will be taken and analyzed (repeat steps 588-592 of FIG. 2D). If the stored temperature (Variable 3) is less than or equal to (or alternatively less than) the cooling temperature set point of 97\degree F. (ninety-seven degrees Fahrenheit), or “Air Temperature is \( \leq 97\degree F \)” (at step 592 of FIG. 2D), the cooling cycle will be terminated, with the cooling unit 150 and HVAC blower 130 being deactivated (at step 594 of FIG. 2D). The system will then initiate another time period between air sample cycles (by repeating steps 508-512 of FIG. 2A). These processes will repeat until a heating cycle is initiated (steps 560-574 of FIG. 2C), a cooling cycle is initiated (steps 580-594 of FIG. 2D), or the control program 500 terminates.

The foregoing embodiments of the HVAC system and HVAC safety control program provide advantages over currently available devices. The HVAC safety control program provides protection for HVAC systems, and the structural components of the building which houses the HVAC systems shall an associated thermostat fail. This includes, but is not limited to mechanical failure, electrical failure, or failure causing “runaway” HVAC system operation. The HVAC safety control program will advantageously take over and maintain operation of the HVAC system when a thermostat fails. In addition, the HVAC safety control program also provides notice of a thermostat failure. For example, an home owner who is not home at the time of the failure will become aware of the failure, aware of action of the HVAC safety control program, and can react accordingly to resolve the failure. These and other advantages may be realized from one or more embodiments of the HVAC system and HVAC safety control program disclosed herein.

Although various representative embodiments of this invention have been described above with a certain degree of particularity, those skilled in the art could make numerous alterations to the disclosed embodiments without departing from the spirit or scope of the inventive subject matter set forth in the specification and claims. Joiner references (e.g., attached, coupled, connected) are to be construed broadly and may include intermediate members between a connection of elements and relative movement between elements. As such, joiner references do not necessarily infer that two elements are directly connected and in fixed relation to each other. In some instances, in methodologies directly or indirectly set forth herein, various steps and operations are described in one possible order of operation, but those skilled in the art will recognize that steps and operations may be rearranged, replaced, or eliminated without necessarily departing from the spirit and scope of the present invention. It is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative only and not limiting. Changes in detail or structure may be made without departing from the spirit of the invention as defined in the appended claims.

Moreover, some portions of the detailed descriptions herein are presented in terms of procedures, steps, logic blocks, processing, and other symbolic representations of operations on data bits that can be performed on computer memory. These descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. A procedure, computer executed step, logic block, process, etc., is here, and generally, conceived to be a self-consistent sequence of steps or instructions leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a computer system. It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the discussions herein, it is appreciated that throughout the present invention, discussions utilizing terms such as “receiving,” “sending,” “generating,” “reading,” “invoking,” “selecting,” and the like, refer to the action and processes of a computer system, or similar electronic computing device, including an embedded system, that manipulates and transforms data represented as physical (electronic) quantities within the computer system.

Although the present invention has been described with reference to particular embodiments, persons skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

What is claimed is:

1. A method for operating an HVAC system comprising: determining whether a failure of a thermostat in operable communication with an HVAC system has occurred; activating a safety control program upon determining the thermostat failure has occurred, wherein the safety control program resides on electronically readable storage medium in operable communication with the HVAC system; resetting a first timer; determining if an amount of time in the first timer exceeds a first time period; increasing the amount of time remaining in the first timer by a first time increment if the amount of time remaining in the first timer does not exceed the first time period; activating an HVAC system blower when the time remaining first timer exceeds the first time period; measuring a temperature of conditioned air on a temperature sensor, wherein the temperature sensor is in communication with the safety control program and is not associated with the failed thermostat; determining whether the temperature of conditioned air is less than a preset minimum temperature; activating an HVAC system heating unit if the conditioned air is less than the preset minimum temperature;
operating the heating unit until the conditioned air is greater than a heating temperature set point; determining, if the conditioned air is not less than the preset minimum temperature, whether the temperature of conditioned air is greater than a preset maximum temperature; activating an HVAC system cooling unit if the conditioned air is greater than the preset maximum temperature; operating the cooling unit until the conditioned air is less than a cooling temperature set point; and returning, if the temperature of conditioned air is not greater than the preset maximum temperature, to the step of resetting the first timer.

2. The method of claim 1, wherein the first time period is preset.

3. The method of claim 1, wherein the first time period equals thirty minutes.

4. The method of claim 1, wherein the first time increment equals one second.

5. The method of claim 1, wherein the step of determining whether the temperature of conditioned air is less than a preset minimum temperature further comprises determining whether the temperature of conditioned air is less than or equal to the preset minimum temperature.

6. The method of claim 1, wherein the step of activating an HVAC system heating unit if the conditioned air is less than the preset minimum temperature further comprises activating an HVAC system heating unit if the conditioned air is less or equal to the preset minimum temperature.

7. The method of claim 1, wherein the step of operating the heating unit until the conditioned air is greater than a heating temperature set point further comprises operating the heating unit until the conditioned air is greater than or equal to the heating temperature set point.

8. The method of claim 1, wherein the step of determining, if the conditioned air is not less than the preset minimum temperature, whether the temperature of conditioned air is greater than a preset maximum temperature further comprises determining, if the conditioned air is not less than the preset minimum temperature, whether the temperature of conditioned air is greater than or equal to a preset maximum temperature.

9. The method of claim 1, wherein the step of activating an HVAC system cooling unit if the conditioned air is greater than the preset maximum temperature further comprises activating an HVAC system cooling unit if the conditioned air is greater than or equal to the preset maximum temperature.

10. The method of claim 1, wherein the step of operating the cooling unit until the conditioned air is less than a cooling temperature set point further comprises operating the cooling unit until the conditioned air is less than or equal to a cooling temperature set point.

11. The method of claim 1, wherein the second time period equals three minutes.

12. The method of claim 1, wherein the preset minimum temperature equals forty degrees Fahrenheit.

13. The method of claim 1, wherein the preset maximum temperature equals one hundred degrees Fahrenheit.

14. The method of claim 1, wherein the heating temperature set point equals forty-three degrees Fahrenheit.

15. The method of claim 1, wherein the cooling temperature set point equals seventy-three degrees Fahrenheit.

16. The method of claim 1, wherein the temperature sensor is provided in an air return duct.

17. The method of claim 1, wherein after the step of activating an HVAC system blower when the time remaining first timer exceeds the first time period, further comprising: resetting a second timer; determining if an amount of time in the second timer exceeds a second time period; increasing the amount of time remaining in the second timer by a second time increment if the amount of time remaining in the timer does not exceed the second time period; and measuring the temperature of conditioned air on a temperature sensor when the second timer exceeds the second time period.

18. The method of claim 17, wherein the second time period is three minutes.

19. The method of claim 17, wherein the second time increment is one second.

20. A method for operating an HVAC system upon thermostat failure comprising: activating an HVAC safety control program; resetting a first timer; determining if an amount of time in the first timer exceeds a preset length of time between air sampling cycles; increasing the amount of time remaining in the first timer by a first time increment if the amount of time remaining in the first timer does not exceed the preset length of time between air sampling cycles; activating an HVAC system blower when the time remaining first timer exceeds the preset length of time between air sampling cycles; measuring a temperature of conditioned air on a temperature sensor, wherein the temperature sensor is in communication with the HVAC safety control program; determining whether the temperature of conditioned air is less than a low temperature limit set point; activating an HVAC system heating unit if the conditioned air is less than the low temperature limit set point; operating the heating unit until the conditioned air is greater than a target heating temperature set point; determining, if the conditioned air is not less than the low temperature limit set point, whether the temperature of conditioned air is greater than a high temperature limit set point; activating an HVAC system cooling unit if the conditioned air is greater than the high temperature limit set point; operating the cooling unit until the conditioned air is less than a target cooling temperature set point; and returning, if the temperature of conditioned air is not greater than the high temperature limit set point, to the step of resetting the first timer.

* * * * *