Abstract: A vacuum sewage system is provided having a sump pit (12) and a collection station (20) connected by a conduit (22). When a vacuum interface valve (30) is opened sewage is transported from the sump pit to the collection station by a pressure differential. A valve position sensor (40) associated with the valve is sensed by a valve monitoring system. The monitoring system is adapted to broadcast a wireless signal of valve status. A computer receives the broadcast signal and notifies an operator of the valve condition.
ABSTRACT

A vacuum sewage system is provided having a sump pit (12) and a collection station (20) connected by a conduit (22). When a vacuum interface valve (30) is opened sewage is transported from the sump pit to the collection station by a pressure differential. A valve position sensor (40) associated with the valve is sensed by a valve monitoring system. The monitoring system is adapted to broadcast a wireless signal of valve status. A computer receives the broadcast signal and notifies an operator of the valve condition.
VACUUM SEWAGE SYSTEM WITH WIRELESS ALARM

FIELD OF THE INVENTION

[0001] This invention relates to a wireless alarm for a vacuum sewage system and a vacuum sewage system incorporating a wireless alarm system.

BACKGROUND OF THE INVENTION

[0002] The present invention relates generally to vacuum sewerage transport systems for conveying sewage collected in a holding sump to a downstream collection vessel maintained under the influence of vacuum or subatmospheric pressure, and more specifically to a wireless alarm or alarm system that signals when an undesired condition is present in the vacuum sewage system, e.g. a hung valve or undesired line pressure condition.

[0003] Vacuum sewage systems are becoming increasingly more popular, especially where common gravity-type sewage systems are unsuitable due to topographical (e.g., uphill gradient from sewage entry point to collection point) and/or underground conditions (e.g., rocks, pipes, and other underground barriers which reduce the depth at which pipes need to be buried to provide continuous downhill gradient). In general terms, in a vacuum sewage system sewage at atmospheric pressure is moved by means of differential pressure through a transport conduit maintained at vacuum or subatmospheric pressure by means of a vacuum pump operatively connected to a collection vessel.

[0004] A typical and basic vacuum sewage system configuration is shown in FIG. 1. Referring to FIG. 1, vacuum sewerage system 10 comprises a sump pit 12 buried beneath ground level 13 to which are connected a plurality of gravity lines 14 emanating from sewage sources 16. External gravity vent 18 positioned above ground ensures that sewage reaches sump pit 12 at or around atmospheric pressure. Located above ground a distance away from sump pit 12 is a vacuum collection station containing a collection vessel 20 maintained at vacuum or subatmospheric pressure by means of vacuum pumps. Vacuum
collection vessel 20 is operatively connected to sump pit 12 by means of a vacuum transport conduit 22. The vacuum transport conduit may be laid in a number of configurations. For example, it may be provided with "pockets" in which the sewage is collected so as to form a plug that entirely fills the cross-sectional bore of the conduit. The sewage plug is moved by means of differential pressure through the conduit in an integral condition. U.S. Pat. No. 3,115,148 issued to Liljendahl, and U.S. Pat. No. 3,730,884 issued to Burns et al. discloses such "plug-flow" systems. More preferably, the conduit portion leading to each pocket or low point is sloped such that the low point will not be filled with sewage upon completion of a sewage transport cycle, and an equalized vacuum or subatmospheric pressure condition is communicated instead throughout the conduit network. As taught by U.S. Pat. No. 4,179,371 issued to Foreman et al., a sewage/air mixture in such a "two-phase flow" system is swept along the conduit during a transport cycle, so that the sewage can travel a greater distance than is possible with a plug-flow system.

[0005] In the vacuum sewage system shown in FIG. 1, a top panel 24 of sump pit 12 is connected to the sidewalls thereof in a sealed relationship in order to provide a pressure-tight vessel. Positioned on top of the top panel 24 is valve pit 26, which is accessed at ground level by a manhole cover 28. Located within valve pit 26 is vacuum interface valve 30. Examples of interface valves may be found in U.S. Pat. Nos. 4,171,853, 5,078,174, 5,082,238, 5,259,427, 5,326,069 and 5,282,281, owned by the assignee of the present invention. Generally, the vacuum interface valve 30 is operatively connected to sump pit 12 by means of suction pipe 36. When the sewage level in the sump pit reaches a predetermined evacuation level, a sensor-controller (not shown) operatively connected to valve 30 triggers the opening of valve 30 and a sewage transport cycle commences, whereby sewage from the sump pit is transported through transport conduit 22 to collection vessel 20 due to the pressure differential between the sump pit 12 (atmospheric pressure) and the collection vessel 20 (vacuum or subatmospheric pressure). When the pressure condition in the valve sensor-controller reaches a predetermined level, the sensor-controller returns the valve to a closed position to terminate the sewage transport cycle. A valve sensor-controller found to be particularly suitable in vacuum sewage systems is
described more fully in U.S. Pat. No. 4,373,838 issued to Foreman et al, which is hereby incorporated by reference.

[0006] Despite advancements made in valve and valve controller designs, problems with hung valves (i.e., valves stuck in an open position) still exist. Hung valves most often occur due to mechanical valve failure, obstructions that prevent the valve from closing, moisture in the valve controls or freezing winter conditions.

[0007] When a valve is hung open, the pressure differential required by the system is compromised, impairing system performance. Significant maintenance costs are associated with the identification and repair of hung valves. Moreover, the system may be inoperative for long periods of time due to unawareness of the problem. Localized alarms have been used to signal a malfunction in the system and produce a visual (light) and/or audible (buzzer) alarm signal, but very often these signals go undetected for long periods of time. Telephone alarm dialers have also been used to warn operators that low vacuum or other malfunction at a vacuum station, but such systems are frequently damaged and rendered ineffective due to lightning strikes.

[0008] For the foregoing reasons, there is a need for a vacuum system that includes a warning or notification system to signal to the sewage system operator that a valve is hung open or to signal to the operator other important sewage system conditions, such as high sewage levels in the sump or low vacuum level in a vacuum sewer main.

[0009] The present invention relates to a wireless notification system that transmits signals to the sewage system operator when there is a malfunction (e.g., a hung valve) or other undesired condition (e.g., inadequate vacuum pressure conditions in transport lines) in the vacuum sewage system. Additional objects and advantages of the present invention will become apparent and a more thorough and comprehensive understanding may be had from the following description taken in conjunction with the accompanying drawings forming a part of this specification.
SUMMARY OF THE INVENTION

[0010] In one embodiment of the present invention there is provided a vacuum sewage system having a first conduit associated with a vacuum source for creating a pressure vacuum in the vacuum sewage system and a second conduit in fluid communication with the first conduit. A valve is operably associated with the second conduit and a valve position sensor capable of sensing whether the valve is open or closed is associated with the valve. The monitoring system further includes a valve position receiver for receiving a signal from the valve position sensor. The valve position receiver is designed and configured such that it is capable of broadcasting a signal signifying that the valve is in an open position. The system also includes a computer for receiving the signal from the valve position receiver. Preferably, the computer is located at a central vacuum station where the system operator is housed and receives signals from multiple valve position receivers associated with multiple valve pits. Alternatively or in addition to a central computer, the system includes a portable receiver for receiving signals from the associated valve position receivers allowing maintenance and operations personnel in the field to monitor valve positions.

[0011] In another embodiment of the present invention, the valve position receiver is set to broadcast a signal only if the valve position receiver receives an open valve signal from the valve position sensor for a duration greater than a predetermined period of time.

[0012] In yet another embodiment of the invention, the signal broadcast to the computer provides an identifier associated the valve position receiver and the duration the valve was in an open position.

[0013] In yet another embodiment of the invention, the computer and/or portable receiver is configured to receive and log valve-open signals from the valve position receiver.

[0014] In yet another embodiment of the invention, the vacuum sewage system includes a plurality a valves, with at least one valve position sensor associated with each valve. In
this configuration, each valve position sensor is designed to sense whether the valve associated therewith is open and a valve position receiver is associated with each valve position sensor for receiving a signal from the respective valve position sensor. The valve position receivers broadcast signals to the computer or portable monitoring receiver indicating when a valve or valves are in an open position. In a preferred embodiment, the signal broadcast to the computer provides (1) an identifier associated with the valve position receiver from which the signal emanated and (2) the duration the valve(s) was in an open position.

[0015] In yet another preferred embodiment of the present invention, system conditions other than or in addition to a hung valve are sensed and a signal is transmitted to the central computer or portable receiver respecting such other condition(s) in order to allow remote monitoring of the vacuum sewage system. Such other system conditions that can be monitored include high sewage levels in the sump and low vacuum level in the vacuum sewer main.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a diagrammatic representation of a typical vacuum sewage transport system;

[0017] FIG. 2 is a diagrammatic representation of a vacuum sewage transport system including a hung valve notification system embodying the present invention;

[0018] FIG. 3 is a perspective view of a the valve position receiver of the present invention;

[0019] FIG. 4 is a diagrammatic representation of a central monitoring station and multiple valve pits with a valve position sensor associated with each pit.

[0020] FIG. 5 is perspective sectional view of the valve position sensor mounted on the valve.
DETAILED DESCRIPTION

[0021] Preferred embodiments of the vacuum sewage system of the present invention are shown in FIGs. 2 - 4. Referring to FIG. 2, vacuum sewerage system 10 comprises sump pit 12 buried beneath ground level 13 to which is connected gravity line 14 which receives sewage or waste water from a sewage source such as a residential or commercial building. An external gravity vent 18, which protrudes above-ground, is connected to gravity line 14 and ensures that sewage reaches sump pit 12 at or around atmospheric pressure. Located a distance away from sump pit 12 is a vacuum collection station containing a collection vessel (see FIG. 1 - ref. 20) maintained at vacuum or subatmospheric pressure by means of a vacuum pump(s). The vacuum collection vessel is operatively connected to sump pit 12 by means of a vacuum transport conduit 22. A top panel 24 of sump pit 12 is connected to the sidewalls thereof in a sealed relationship in order to provide a pressure-tight vessel.

[0022] Positioned on top of the top panel 24 is valve pit 26, which is accessed at ground level by a manhole cover 28. Located within valve pit 26 is vacuum interface valve 30. Vacuum interface valve 30 is operatively connected to sump pit 12 by means of suction pipe 36. When the sewage level in the sump pit reaches a predetermined evacuation or discharge level, a sensor-controller (not shown) operatively connected to valve 30 triggers the opening of valve 30 and a sewage transport cycle commences, whereby sewage from the sump pit is transported through transport conduit 22 to collection vessel 20 (FIG. 1) due to the pressure differential between the sump pit 12 (atmospheric pressure) and the collection vessel (vacuum or subatmospheric pressure). When the pressure condition in the valve sensor-controller reaches a predetermined level, the sensor-controller returns the valve to a closed position to terminate the sewage transport cycle.

[0023] Still referring to FIG. 2, a valve position sensor 40 is operably connected to or associated with valve 30. Valve position sensor 40 operates to detect or sense when valve 30 is in the open position. In a preferred embodiment of the invention, the valve position sensor senses the valve position using a reed switch activated by a magnet mounted internally in a valve piston cup. In operation, the magnet moves with the valve operation. Referring to FIG. 5, a preferred reed switch-type valve position sensor is
depicted. As shown in FIG. 5, valve position sensor 40 includes a reed switch mounted in housing 54 (e.g., a nylon housing). In the operation of the valve, a magnet 50 is slid into a clip 56, which is pushed into a channel 58 on the inside of the piston cup 52. The magnet clip 56 is held in place by interference fit with the piston cup 52. Preferably, a notch on the lower housing is provided to indicate the center of the magnet for alignment during assembly. When the valve is in the closed position, the magnet 50 is aligned with the position sensor 40, and the magnetic field causes the opening of the reed switch. When the valve is in the open position, the magnet 50 is moved away from the position sensor 40, and the magnetic field is weakened, allowing the reed switch normally closed (NC) contacts to be in the closed position. Therefore, the valve position sensor provides an open contact output with the valve in its closed position. When the valve is opened, the valve position sensor provides a closed contact output (this example is for the NC contacts). Although the reed switch is described above as a preferred means of sensing valve position, any type of electrical switch could be installed in the valve and activated by the valve component movement.

[0024] Referring to FIGS. 2 and 3, upon detection of an open valve, the valve position sensor 40 transmits a signal through wire 62 housed in conduit 60. Conduit 60 is preferably constructed of a material that prevents water from permeating into the conduit, such as a PVC or other plastic material. Wire 62 is connected to a valve position notification device 70 (also called a hung valve notification device or HVN device), which is capable of receiving and processing the signal (and hence information) received from the valve position sensor 40 through signal wire 62. Valve position notification device 70 is a wireless communication device capable of broadcast or transmitting a signal that conveys the information received from the valve position sensor. Most preferably, device 70 works in conjunction with the valve position sensor to transmit to a remote computer (e.g., a computer at a central vacuum station) or to portable receiving device so as to alert the vacuum system operator when a valve is hung open. Referring to FIG. 3, the valve position notification device includes a housing 71, removable lid 72 and antenna 73. Within housing 71 is a circuit board 74 that includes a wireless transmission card. The valve notification device is programmed with a predetermined maximum valve-open time, preferably and typically between about 1-10 minutes. If the valve
position notification device receives a signal from the position sensor for a duration greater than the predetermined set time, it broadcasts a signal to the computer at the vacuum station or the portable receiving device so that maintenance personnel can be dispatched to the location where the valve is hung open.

[0025] Because a vacuum sewage system typically has multiple users (i.e., valve pits) and multiple valves (See FIG. 4), an identifier (such as a number) (a unit ID) is preferably assigned to each valve position notification device. Again, if the valve position notification device receives a signal from the position sensor for a duration greater than the predetermined set time, it broadcasts a signal containing the unit ID and duration the valve has remained open. Based on the unit ID, maintenance personnel can then go directly to the hung open valve and repair the problem. Dipswitches 75 are preferably located on the circuit board 74 in order to allow the unit ID to be changed and to allow the signal-triggering time (i.e., the maximum valve-open time) to be changed to met the needs of a particular valve pit. Preferably, the valve position notification device also includes a cycle counter 78. The cycle counter is used to count each valve operation, providing a means to detect valves receiving excessive flows or to assist with the billing of customers based on sewage flow. In operation, the cycle counter is actuated by an internal magnet mounted in the piston of the valve 30. A cycle count is added whenever the piston inside the valve operator lifts from its seated position. Preferably, the counter includes a delay period (e.g., 9 seconds) after receiving a count where it will not accept another input. This is to prevent cycle fluctuations from causing erroneous cycle counts. With this delay period the counter is capable of correctly counting normal low frequency input, up to the peak flow the valve is rated for.

[0026] In a preferred embodiment, the valve position notification unit operates at a frequency between 902-928 MHz and voltage of 6.0 Vdc and has a range of at least about 1.5 miles. The Maxstream Xtend RF modem has been found to be particularly suitable for use in the present system.

[0027] In another preferred embodiment, the valve position notification device is powered by solar panels 16 and a 9-volt rechargeable battery 77. To conserve power, the
unit preferably "wakes up" only every 20 seconds (or other regular interval) to check for a signal from the valve position sensor.

[0028] Thus, generally and preferably, the valve position notification device 70 is a device that includes a programmable chip, an input for receiving input from the valve position sensor, a connection to adjust time delays, a cycle counter, means to send a signal to the operator (e.g., to a computer at a vacuum station) that identifies the pit or unit with a malfunctioning valve or other problem, and a power source (e.g., a battery).

[0029] Referring to FIG. 4, there is shown a diagram of a vacuum sewage system having multiple valve pits having assigned pit ID numbers 1-14. A vacuum station 100 serving the multiple valve pits and system users is shown. Located on the outside of station 100 is an antenna 102 and within station 100 is a computer 104 capable of receiving signals (and hence information) through the antenna that has been transmitted by the valve position notification devices located at each valve pit. Preferably, the computer is configured to log alarm signals from the valve position notification devices and is capable of displaying a map of the valve pits, such as that shown in FIG. 4. In operation, upon receiving an alarm signal from a valve position notification device, which signal contains the ID number associated with the malfunctioning valve, the computer will display on the map or otherwise indicate the particular valve(s) that has malfunctioned. Although FIG. 4 shows multiple valves sharing a common vacuum line, the valve position notification device and the computer or portable signal receiver need not be on the same vacuum line, eliminating the need for multiple computers when multiple vacuum stations are present.

[0030] In another preferred embodiment of the invention, the valve position notification device includes a battery-power monitor. The benefit of this optional feature is that if at any time the battery voltage approaches the minimum operating voltage, the valve position notification unit sends an alarm signal to the computer, with the assigned unit ID number and an indication that the battery needs to be replaced.

[0031] Although the description of the present invention has primarily focused on the detection and signaling of hung valves, other critical or significant sewage system
conditions can be detected and alarm signals transmitted for immediate attention by maintenance personnel. For example, the wireless alarm system described herein can be configured and used to detect high sewage levels in the sump, which fluid levels can be detected, for example, by well-known liquid float-type switches having a non-powered, dry contact with two-wire output. Additionally, the wireless alarm system described herein can be configured and used to detect low vacuum level in a vacuum sewer main, which vacuum levels can be detected, for example, by well-known non-powered, dry contact, two-wire output pressure switches used for monitoring vacuum levels.

[0032] Having thus described in detail a preferred selection of embodiments of the present invention, it is to be appreciated and will be apparent to those skilled in the art that many physical changes could be made in the apparatus without altering the inventive concepts and principles embodied therein.
THAT WHICH IS CLAIMED IS:

1. A vacuum sewage system comprising:
   a first conduit associated with a vacuum source for creating a pressure vacuum in
   said vacuum sewage system;
   a second conduit in fluid communication with said first conduit, said second
   conduit having a valve associated therewith;
   a valve position sensor associated with said valve, said sensor being capable of
   sensing whether the valve is open or closed;
   a valve position receiver for receiving a signal from said valve position sensor, said
   valve position receiver being capable of broadcasting a signal signifying that the valve is
   in an open position; and
   a means for receiving said signal.

2. The vacuum sewage system as set forth in claim 1 wherein:
   said valve position receiver broadcasts said signal only if said valve position
   receiver receives an open valve signal from said valve position sensor for a duration
   greater than a predetermined period of time.

3. The vacuum sewage system as set forth in claim 1 wherein:
   said signal broadcast to said signal receiving means provides an identifier
   associated with said valve position receiver and the duration said valve was in an open
   position.

4. The vacuum sewage system as set forth in claim 1 wherein:
   said signal receiving means is configured to receive and log valve-open signals
   from said valve position receiver.

5. The vacuum sewage system as set forth in claim 1 further comprising:
   a plurality of valves;
   at least one valve position sensor associated with each valve in said plurality of
   valves;
each of at least one valve position sensor being capable of sensing whether the valve associated therewith is open; and

a valve position receiver associated with each valve position sensor for receiving a signal from the respective valve position sensor, each said valve position receiver being capable of broadcasting a signal to said signal receiving means signifying that the valve associated therewith is in an open position.

6. The vacuum sewage system as set forth in claim 5 wherein:

said signal broadcast to said signal receiving means provides an identifier associated with said valve position receiver and the duration said valve was in an open position.

7. The vacuum sewage system as set forth in claim 6 or 5 wherein:

said signal receiving means is configured to receive and log valve-open signals from each of said valve position receivers.

8. The vacuum sewage system as set forth in claim 1 wherein:

said signal receiving means is a computer.

9. The vacuum sewage system as set forth in claim 1 wherein:

said signal receiving means is a portable signal receiving device.
### A. CLASSIFICATION OF SUBJECT MATTER

**INV.: E03F1/00**

According to International Patent Classification (IPC) or to both national classification and IPC:

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols):

- E03F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched:

Electronic data base consulted during the international search (name of data base and, where practical, search terms used):

- EPO-Internal

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C

See patent family annex

**Special categories of cited documents**

- 'A': document defining the general state of the art which is not considered to be of particular relevance
- 'E': earlier document but published on or after the international filing date
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- 'P': document published prior to the international filing date but later than the priority date claimed

**Date of the actual completion of the international search**

4 July 2007

**Date of mailing of the international search report**

17/07/2007

**Name and mailing address of the ISA**

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**Authorized officer**

Gei senhofer, Michael
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