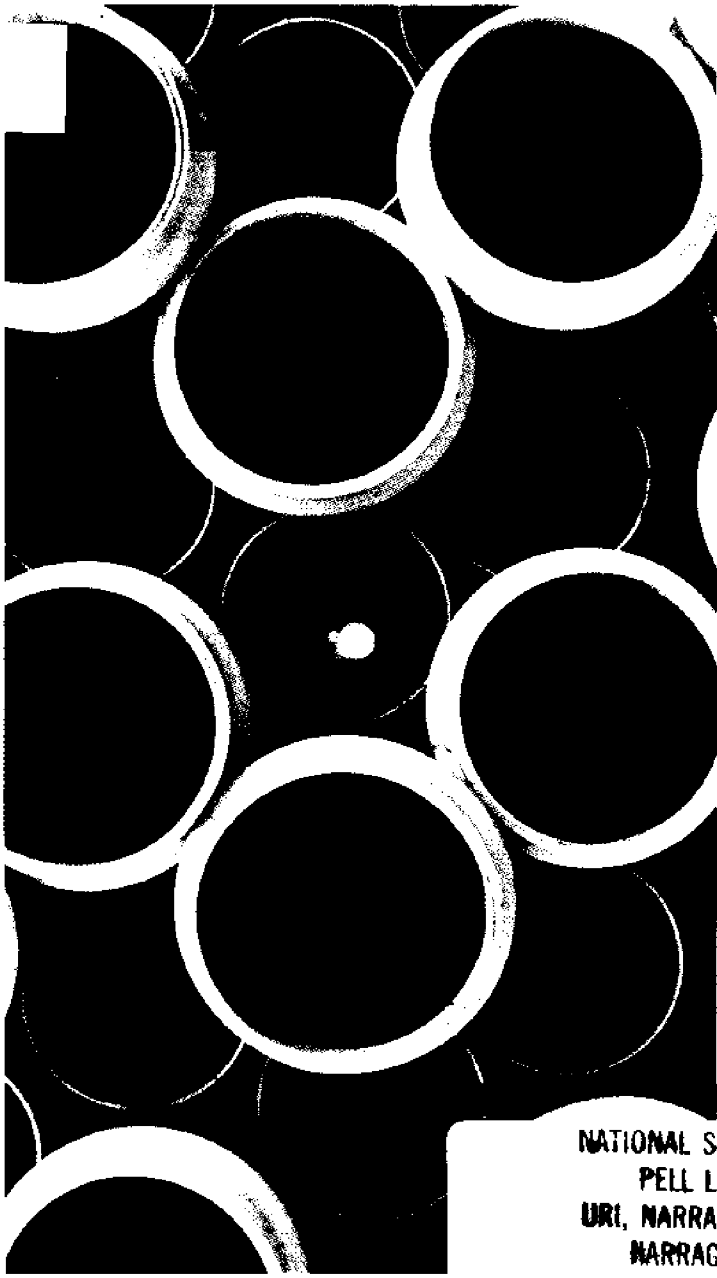
# Pressure Dosed Septic Systems:

## Electrical Components and Maintenance







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# Pressure Dosed Septic Systems:
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# Table of Contents

# Preface

This manual describes dosing controls and accessories suitable for pressure-dosed septic systems and discusses how to select, use and maintain them. This information is based on evaluation of experimental systems and on practical experience gained from observing systems installed in North Carolina since 1977. This manual should be used as a supplement to the design manuals for the low-pressure pipe and mound systems published by UNC Sea Grant.

Although many pressure-dosed systems are simple, all must be designed, installed and maintained with care. Systems should be designed in cooperation with permitting agencies to ensure that all safety and performance regulations are met.

Description of components in the manual does not imply endorsement of any name brand products. This manual is not the final word on controls for pressure-dosed systems. New products are being developed; older ones, improved. Also, some products may not perform as well as anticipated in the long run.

The use of microelectronic circuitry undoubtedly will lead to a new group of components that can be used in pressure-dosed systems. These developments will provide more choices and flexibility when used with the principles in this manual.

CHAPTER 1

# Introduction to Electrical Components

## Why electrical components are needed

Conventional septic systems are simple and inexpensive. They have no moving parts and require no power and little maintenance. But they are not suitable for use on much of the land currently available for development. Researchers designed several alternative systems for use in soils unsuitable for conventional systems. Although these systems are more expensive and contain a variety of parts—pumps, motors, switches, wiring and valves—that must be carefully installed and maintained, they are often necessary.

Pressure dosing, the most widely used and successful alternative technique in North Carolina, improves septic system performance in poor soils. Rather than using a conventional gravity-fed drain field, pressure-dosed systems pump doses of effluent into shallow, narrow trenches. Pressure dosing offers three advantages over conventional gravity loading:

- distribution of effluent throughout the absorption area,
- alternating dosing and resting cycles, and
- shallow placement of distribution laterals.

Three alternative systems installed in North Carolina—low-pressure pipe (LPP), mound, and recirculating sand filter systems—use pressure dosing. The design of LPP and mound systems is discussed in separate manuals published by UNC Sea Grant (Cogger et al., 1982a, 1982b).

## Operation of alternative systems

The LPP is a shallow, pressure-dosed, soil-absorption system (Figure 1-1). It consists of:

- a two compartment septic tank,
- a pumping chamber,
- a submersible effluent pump and level-controls,
- a high-water alarm,
- a supply line and manifold,
- distribution laterals, and
- suitable area and depth of soil.

When effluent rises to a height that activates the level-control, the pump turns on and effluent moves through the supply line and distribution laterals. These laterals are PVC pipes that contain small holes (5/32 inch to 1/4 inch) spaced 3 to 5 feet apart. The pipes are placed in narrow trenches 6 to 18 inches deep, spaced 5 feet or more apart. Under low pressure [0.7 to 2 pounds per square inch (psi)] supplied by the pump, septic tank effluent flows through the holes and into the trenches. It diffuses from the trenches into the soil where it is treated.

The pump stops when the effluent drops to a height that deactivates the level-control. The level-control is set to pump effluent two to four times daily. Periodic resting periods permit aerobic treatment of the effluent. If the pump or level-control fail, the effluent will rise to the level of the alarm control switch. The alarm signals the homeowner of failure.

This manual describes the selection, installation and maintenance of the control components in detail and discusses some aspects of maintenance not described in the LPP and mound manuals.

## Choosing and using pumps and controls

### *Equipment selection*

Proper selection of pumps and controls is vital. Manufacturers market a wide variety of devices, but many are suitable for clear water, not effluent. They fail in the corrosive and abrasive sewage environ-

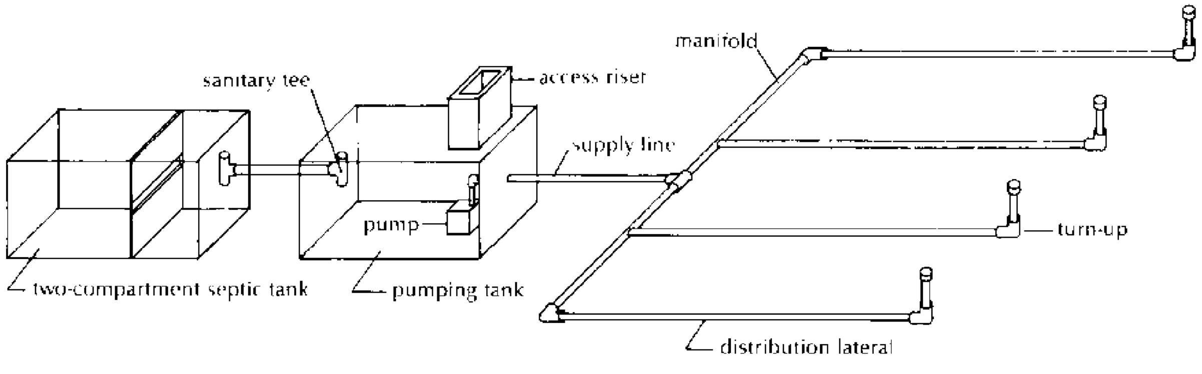



**Figure 1-1:** *basic components of a low pressure pipe system*

ment. Other controls lack the adjustability and flexibility needed for on-site system design. Some pumps cannot handle the required volume of effluent. Other expensive pumps are designed for more severe conditions than found in septic systems, and no benefits are gained from the extra money spent.

In areas where pressure-dosed septic systems have been installed, pump and electrical suppliers usually carry the proper equipment. But in areas where these systems are new, the proper devices are often unavailable. It is important to use the right equipment, even if it has to be ordered specially.

### *Importance of maintenance*

Pressure-dosed systems require more frequent inspection and maintenance than conventional systems. Lack of maintenance can cause system failure. Homeowners can easily inspect and maintain pumps and controls. Inspection, maintenance and trouble-shooting procedures are discussed in Chapter 7.

# CHAPTER 2

# Level-Controls

A level-control switches the effluent pump on and off by responding to changes in the wastewater level in the pumping chamber. Float, electromagnetic and diaphragm level-controls have been tested with pressure-dosed systems (Fig. 2-1).

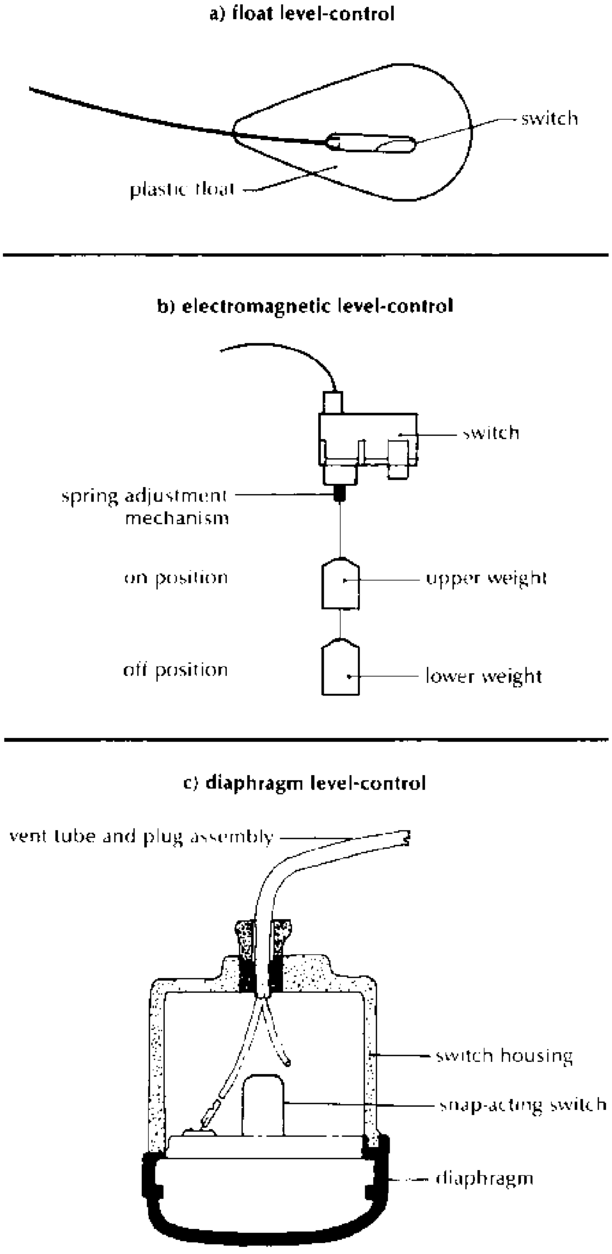



**Figure 2-1:** *types of level controls*

Float level-controls respond to buoyant forces with a float and contain a mercury or reed switch. Electromagnetic level-controls respond with displacement weights and contain an electromagnetic switching mechanism. Diaphragm level-controls sense level changes with a rubber shield and contain a snap-acting switch. Level-controls are available as a part of the effluent pump or as separate units. Level-controls that are part of the pump assembly lack convenience, accuracy and adjustment range. Level-controls separate from the pump are preferred.

A level-control should be:

- resistant to wet and corrosive environments;
- equipped with repeatable, accurate switching;
- adjustable to enable "fine tuning" within a system and to meet drawdown requirements of different systems;
- operable without entanglement;
- easily installed;
- low in maintenance needs; and
- low cost as compared to the total cost of the pressure-dosed system.

This chapter describes the design, operation and evaluation of level-controls. Appendix I provides additional information on these controls. All types of level-controls can be used with a relay.

## Relays

An armature relay, a simple electromechanical device, coordinates the switching of the level-controls and manages the flow of electricity to the effluent pump. The relay contains an electromagnetic coil and contacts. The relays often used to control pumps have normally open (NO) contacts. The contacts close when the coil is energized by the level-control. Once the contacts are closed, power is supplied to the pump (Fig. 2-2).

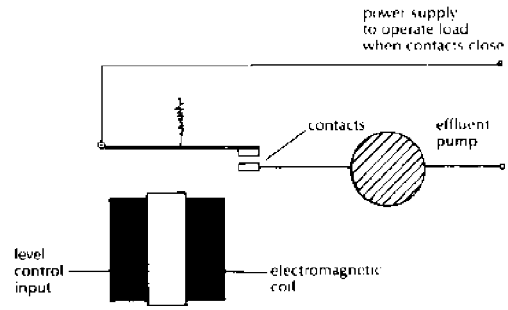



**Figure 2-2:** *normally open armature relay*

Normally closed (NC) relays have contacts that are closed until the coil is energized. This type of relay is used in some alarm control systems.

Latching relays have contacts that remain closed even after initial current has ceased to flow. The contacts must be opened by a manual switch. This type of relay is used in alarm controls also.

## Description and operation of float level-controls

A float level-control consists of a switching mechanism enclosed within a plastic float. The switching mechanism, usually a mercury or reed switch, responds to changes in the float's position as the tank fills or empties. The numerous float level-controls available differ in the following design features: type of switching mechanism, electrical specifications, shape and material of float construction, orientation and attachment of the switching mechanisms, and method of installation within the pumping chamber. As a result, different float level-controls vary in adjustment ranges, load capacities and susceptibilities to contact bounce (intermittent switching due to turbulence in the tank). Choose a float suited for the application.

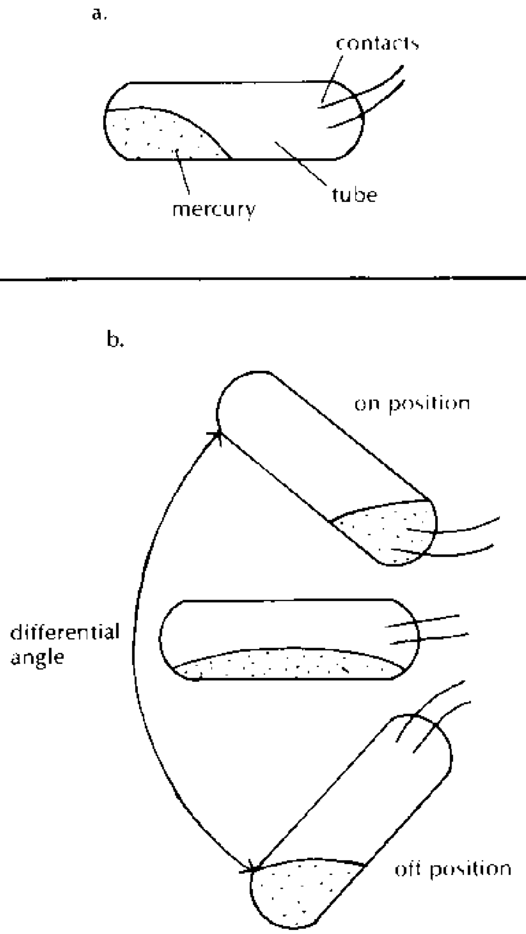



**Figure 2-3:** *mercury switch operation*

response to tilting makes or breaks the contact between the electrodes (Fig. 2-3b). The angle of the tilt from the make to the break position is the differential angle. Mercury switches are well suited for float level-controls because (1) they are built with a wide range of electrical capabilities, (2) they have excellent repeatability and position sensitivity, and (3) they are sealed and isolated from the environment.

Reed switches also are used in float level-controls. They consist of two metallic strips sealed within glass tubing. A ring magnet surrounds the glass tubing. It is free to slide up or down. As the control tilts, the magnet slides past the metallic strips, which are repelled by the magnet and bend toward each other until contact is made. Reverse movement of the magnet opens the switch. The magnet moves rapidly once a critical level is reached. Switching occurs at a definite point and contact bounce is not a problem (Fig. 2-4).

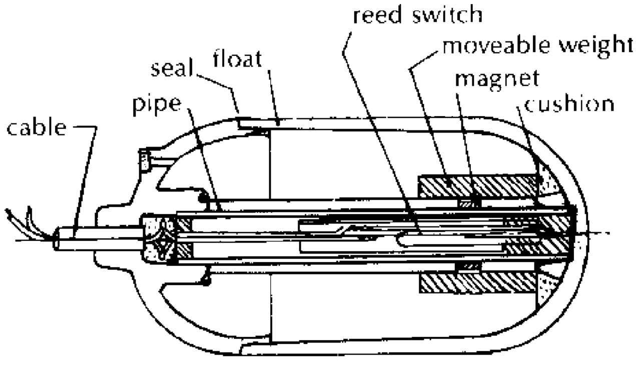



**Figure 2-4:** *float with reed switch*

### *Switching mechanisms*

Mercury switches commonly are used in float level-controls. The switches, hermetically sealed, hydrogen-filled glass tubes, contain stationary electrodes and a pool of mercury (Fig. 2-3a). The mercury's

### *Electrical specifications*

Mercury switches are available with mercury-to-dry-metal contacts or wetted-metal contacts. Mercury-to-dry-metal contact switches are used with alarm floats because little current is drawn and contact bounce is not important for an alarm function. Mercury-to-wetted-metal contacts are suitable for use in differential switches where higher current rating and more accuracy are necessary.

Reed switches possess a limited current switching range. Used with holding relay units, reed switches provide higher current values and convert to NO or NC capabilities.

Switches for level-controls are available in a wide range of switching and current handling capabilities (Table 2-1). Using a switch that has a current value too small for its use can cause injury during installation or maintenance checks.

| Level-control type | Adjustability | Range | Switching accuracy | Corrosion resistance | Installation ease | Evaluation |
|---|---|---|---|---|---|---|
| float level alarm | NA | NA | NA | + | + | + |
| single cannister shape | + | 6.5" to 16" | + | −/+ | + | + |
| single pear shape | + | 10" to 28" | − | + | + | −/+ |
| single triangular pear | + | 10" to 28" | + | + | + | + |
| single disk | + | 5" to 30" | −/+ | + | −/+ | −/+ |
| two-float external relay | + | 5" tank depth | + | + | −/+ | + |
| two-float internal relay | + | 1" to 48" | + | + | + | + |
| electromagnetic level-control | + | 0 tank depth | −/+ | −/+ | −/+ | −/+ |
| diaphragm level-control | − | ≅6" | − | − | + | − |

**Table 2-1:** *level-control evaluation*

## *Float construction*

The switching mechanism is enclosed within a plastic float. The most reliable floats are made of sturdy, inert plastics such as polyurethane foam or an ABS (acrylonitrile butadiene styrene) shell. Available in a variety of shapes (Fig. 2-5), floats provide stability in turbulence and orient the enclosed switching mechanism. Some floats are designed with distinct top and bottom sides and must be mounted correctly to ensure proper operation (Chapter 6). The float must be tightly sealed where the electrical cable enters, and hollow, two-piece floats must be bonded securely to prevent the entrance of moisture or corrosive gases.

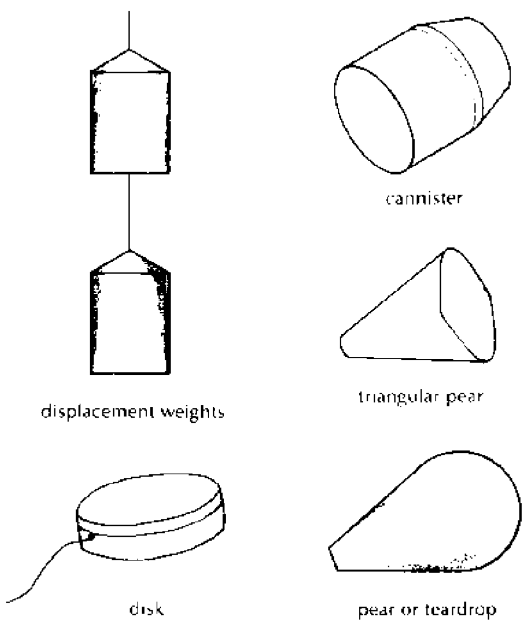



**Figure 2-5:** *float level-control shapes and electromagnetic control displacement weights*

## *Orientation and attachment*

The switching mechanism within a float level-control may be fixed or free to pivot within the float. Foam floats contain a fixed switch, but hollow floats contain a pivoting switch. The type of attachment and movement of the switch affect how accurately a float level-control responds to level changes and how it is affected by turbulence.

The fixed switch shows no external movement as the float changes position. The mercury pool within the switch changes position in response to float movement. The mercury movement may be gradual and equal to float level change or it may be rapid to make contact quickly once a critical level is reached. Rapid mercury movement provides the most accurate switching and the least contact bounce (Fig. 2-3).

Pivoting switches combine the rapid mercury action with the movement of the switch itself. Switching occurs at a definite point and usually is not influenced by turbulence (Fig. 2-6).

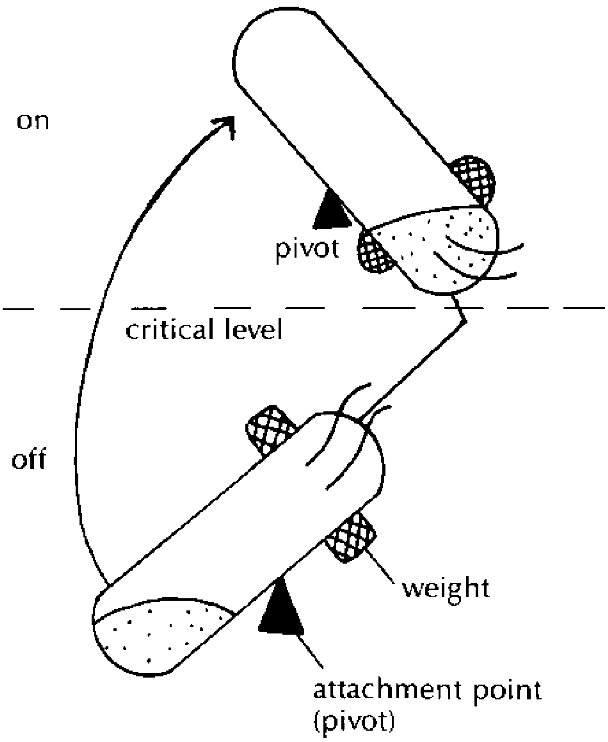



**Figure 2-6:** *pivoting mercury switch*

*Installation*

Float level-controls are attached within the pumping chamber by plastic ties, straps, brackets or special clamps. Some models have lead weights attached to their electrical leads to determine the depth of the level-control and its switching position. Details of installation are covered in Chapter 6.

## Types of float level-controls

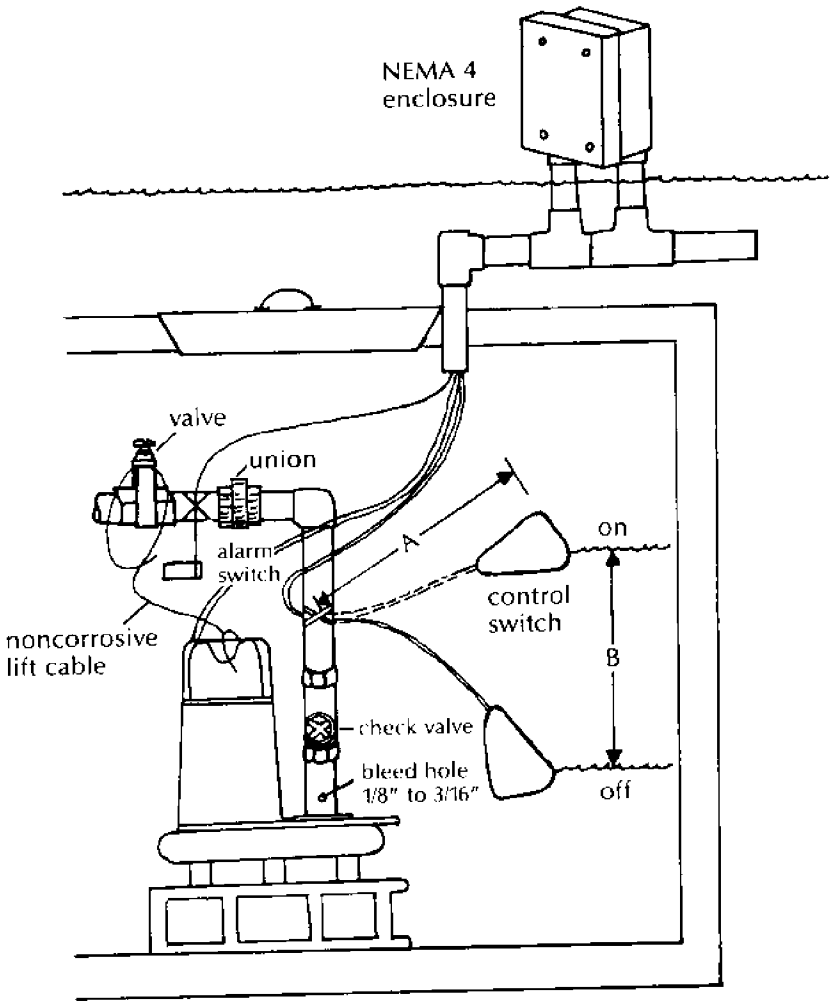
Five basic types of float level-controls are available that use different combinations of the components previously described.

*Alarm floats*

An alarm float is a single float level-control installed within the pumping chamber to detect high wastewater levels and to activate an alarm light or buzzer. A float containing a NO, light-duty, mercury-to-dry-metal contact switch is adequate for alarm sensing. The low amperage is sufficient for alarm circuits, and the susceptibility to contact bounce is of minor importance for this use. Many alarm systems use an alarm float with a holding relay in an external panel. (Alarm systems are discussed in more detail in Chapter 3). This float must not be used for higher current demands. It may explode and cause injury.

*Single and differential floats*

There are two types of single float level-controls. The first type increases switching capabilities with a pivoting mercury-to-mercury contact that is within the float. The second type of float (differential) possesses a fixed switch, but gets increased capabilities from the shape of the mercury-to-mercury or mercury-to-wetted-metal contacts and tube. It is named by its switching or differential angle. Both types may be adjusted by changing the distance from the attachment point to the float (Fig. 2-7).




**Approximate pump cycle**

Tie down A = 4" 6" 8" 10" 12" 14" 16"
Differential B = 10" 12" 14" 17" 20" 24" 28"

**Figure 2-7:** *differential float level-control adjustment and operation*

Neither float type is accurate below 6 inches of drawdown. The differential float increases its switching range with use, creating a gradual increase in pumping volume. A few inches of difference in drawdown can change the volume of the dose to the absorption field considerably. Consequently, choose a control with an adequate operating range.

### *Single float with time delay relay*

A single float that is not designed to handle contact bounce and subsequent pump short-cycling may be used if it is combined with a time delay relay (TDR) (Appendix II). If turbulence causes contact bounce, the electrical signal must go through the TDR prior to energizing the dosing pump. If the TDR is set for 10 seconds, the switch must remain closed for 10 seconds before the relay starts the pump. Thus, short cycling of the pump due to contact bounce will be prevented.

### *Double float with internal relay*

Double float level-controls consist of two sealed floats (an on and off float). Their power cords are molded into one series plug cord. Each float contains a heavy-duty mercury-to-mercury switch and a solid state NO holding relay sealed within the top float. The upper switch, the on float, energizes the holding relay and starts the pump. The relay keeps the pump operating until the wastewater drops to the point where the lower switch, the off float, opens the relay and stops the pump.

This type of control has a wide adjustable pumping range because the dual float and relay system overcomes differential angle and contact bounce problems. It can handle high currents, and the sealed internal relay makes installation simple.

### *Double float with external relay*

This level-control system is similar to the float/internal relay combination, except the relay is placed in a control panel remote from the pumping chamber. The double float can be used in complicated applications by varying the types of relays used. A simplex (one pump) control employs a holding relay, but a duplex or multiplex system (Chapter 4) uses NO relays and an alternating switch.

### *Evaluation*

Float level-controls offer the broadest range of drawdown capabilities and meet the criteria for controlling sewage levels. However, if not properly installed, controls will become entangled. Small drawdowns (0 to 6 inches) are difficult to achieve accurately (Table 2-1).

## Description and operation of the electromagnetic level-control

One basic style of electromagnetic level-control can be found in North Carolina. It consists of three components—an electromagnetic switch assembly, a spring adjustment mechanism and a weight assembly (Fig. 2-1b). As wastewater accumulates in the pumping chamber, the weights become buoyant. This relaxes the spring adjustment mechanism and allows magnetic force to close the snap-acting switch to complete the circuit. As wastewater is withdrawn by the pump, the buoyant force on the weights is reduced. The spring stretches until the force of the magnetic attraction on the switch is overcome and the pump shuts off.

The adjustment range of the electromagnetic control is one to 89 inches. The switching mechanism, available with either NO or NC circuits, allows either pump-down or pump-up operations. For versatility, the control can directly regulate the effluent pumps or be combined with time switches or external control panels.

### *Evaluation*

Fine adjustment and maintenance are very important to the accurate operation of this level-control. Solids collecting on the weights and fatigue of the spring adjustment mechanism can affect switching sensitivity and the amount of drawdown with each dose (Table 2-1). However, the electromagnetic control is especially useful when small drawdowns are desired (1 to 6 inches) or when space within the pumping chamber is a problem. The operation and maintenance of this switch is discussed in detail in Appendix 1.

## Description and operation of the diaphragm level-control

A diaphragm level-control consists of: a plastic switch housing, a rubber diaphragm, a snap-acting switch, and a vent tube and plug assembly. The switch housing is a plastic cup with a rubber diaphragm stretched across the open end. The vent tube and plug assembly is potted through the closed end of the housing. The snap-acting switch is mounted within the housing (Fig. 2-1c).

The diaphragm level-control, which is installed within a pumping chamber, is attached to the effluent pump housing or is suspended as a separate unit. Wastewater level increases within the pumping chamber cause the rubber diaphragm to become concave. The movement of the diaphragm activates the snap-acting switch. Air displaced by the diaphragm movement travels through the vent tube outside of the pumping chamber. As the wastewater level drops, the diaphragm returns to its initial position. The switch opens, and air moves in through the vent tube to fill the space previously occupied by the diaphragm.

### *Evaluation*

The diaphragm level-control has not proven effective because: 1) the rubber diaphragm degrades and affects switching accuracy; 2) the degradation can cause wastewater to enter the switch housing; 3) the vent tube is easily clogged, affecting switching accuracy; and 4) it is not adjustable.

CHAPTER 3

# Alarm and Monitoring Controls

An alarm control is required for pressure-dosed septic systems. It consists of a level-control that is wired to an alarm device (usually a light or buzzer). Placed in the tank, the alarm level-control will activate if the effluent accumulates beyond the normal level, indicating some malfunction of the system.

The alarm system should:

- be on a separate circuit from the pump and its controls,
- be protected from its environment,
- be in a prominent and accessible location,
- be positioned in the pump tank at a level to allow for repairs prior to overflow,
- use a holding relay or similar circuitry that remains closed until the alarm level-control switch opens, and
- have an audible alarm that may be turned off and a visual (flashing light) signal.

## Operation

If wastewater rises within the pumping chamber past the point of normal pump activation (or faster than the pump can empty the chamber), an alarm situation is detected by a NO level-control switch. The alarm switch may be of low amperage since it functions as a pilot within the circuit. When the level-control switch closes, a latching relay closes, activating the alarm device. The latching relay keeps the circuit closed even after initial energizing currents stop flowing. The alarm will continue until the system is manually reset. This requires the attention of the homeowner or operator even if the wastewater drops and the level-control switch opens. Not all alarms have latching relays, and a drop in wastewater will deactivate some alarms.

Some alarm systems use a NC level-control and are wired to signal an alarm when the level-control switch opens. Under this system, the alarm will activate if the alarm circuit is damaged or broken as well as when high water occurs. During normal operation, the NC switch circuit holds open a NC relay that is connected in series with the alarm light. When the switch circuit is broken, the relay is de-energized and snaps shut, closing the circuit with the alarm light.

## Low flow alarms

In some cases two or more pumping chambers may be connected. Overflow from one flows to another. High wastewater levels will not occur in all pumping chambers. To detect a pump or control malfunction in this case, a different alarm system is needed. A pressure switch is installed within the supply manifold. The pump and pressure switch are activated simultaneously by the control switch (level-control or timer). If the pressure switch does not receive wastewater at the preset pressure, it closes and activates an alarm circuit. For example, if the pump does not pressurize the manifold adequately, the alarm will go off.

## Pump counters and time indicators

Electrical impulse counters and elapsed time indicators are used to measure the frequency and length of pump cycles. They can be wired directly to the pump circuit to activate simultaneously with the effluent pump. Counters and time indicators can check the operation of a new system and can provide early warning for potential problems. Unusually frequent or long pump cycles are indicative of heavy wastewater loading, inefficient pumping, ground water infiltration, short cycling, or clogging in the lines. These situations can harm the system if not detected early.

## Permanent versus temporary monitoring devices

Control panels can be ordered that contain monitoring devices. Otherwise they can be added if space allows or installed in a separate enclosure and wired to the pump circuit.

When a permanent monitoring circuit is impractical, the system may be monitored with a mobile unit on a temporary basis. This is a useful tool for health officials and system operators. They can monitor the pump or changes in wastewater level within the pump chamber on an interim basis.

If the pump and level-controls are equipped with plugs, the system can be easily monitored with a mobile monitoring unit (Fig. 3-1). If the pump contains a built-in, level-control switch or is hard wired, the level change can be monitored as an indicator of pump operation. This can be achieved with a level-control switch, a weatherproof enclosure (ammunition box works well) containing time indicators and counters, and an electrical circuit separate from the pump and control circuits (Fig. 3-2). The level-control is installed within the pump chamber to monitor level change and wired between the power supply and the monitoring devices. Its movement activates or deactivates the monitors appropriately.

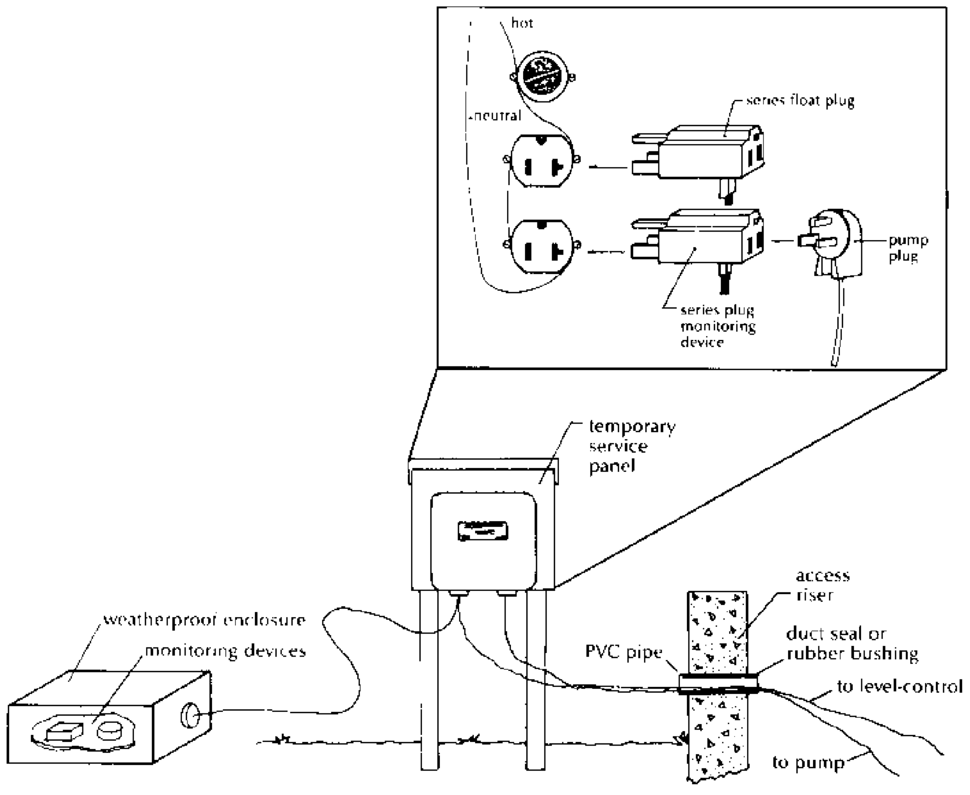



**Figure 3-1:** *mobile monitoring unit for plug-in circuit.*

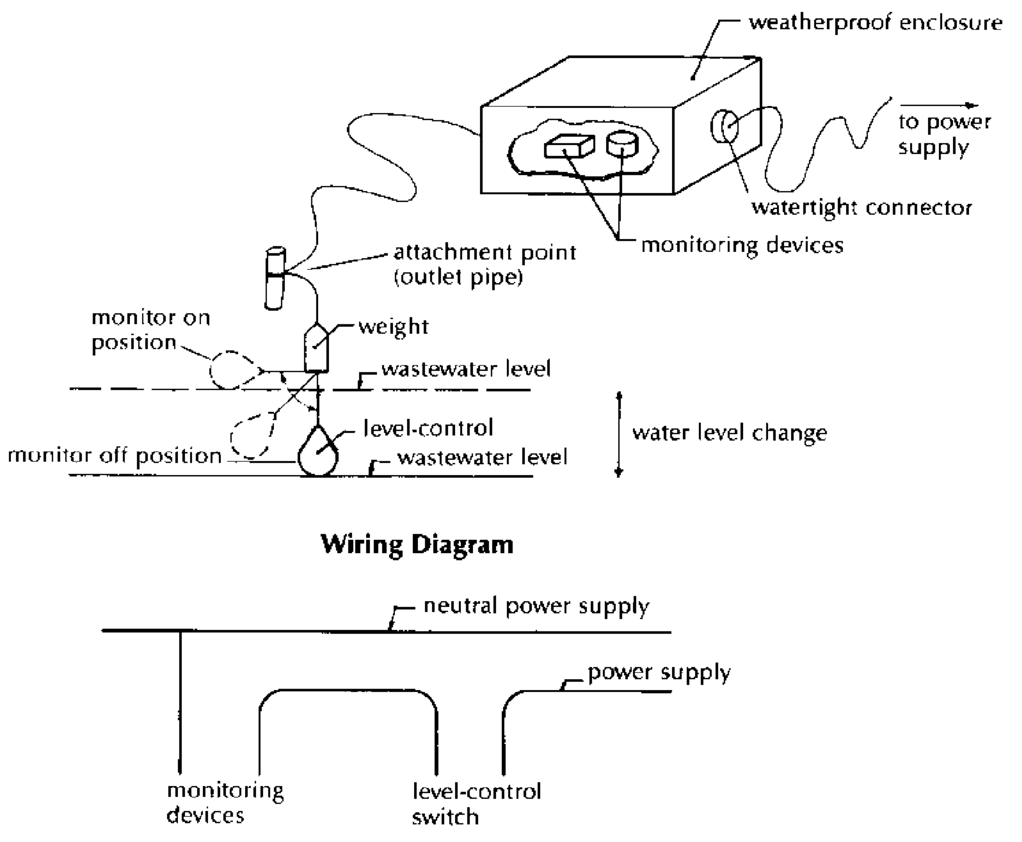



**Figure 3-2:** *mobile monitoring unit for hard wired circuit*

## CHAPTER 4

# Timer-Activated and Multiplex Controls

The basic control devices described in Chapter 2 can be combined with other electrical devices to create control systems to accommodate special applications. This chapter describes timer-activated and multiplex controls—two control systems used frequently in such cases.

## Flow equalization using timer/level-control combination

A time switch in combination with a relay and a level-control is useful in a pressure-dosed system, especially when the system receives a high proportion of the daily or weekly wastewater flow over a short period of time. This is termed "shock loading." The timer and level-control combination distributes the shock load over a longer time span.

A recreational facility, for example, may generate up to 3,500 gallons of wastewater on a weekend and be used minimally the rest of the week. The pumping chamber must accommodate the 3,500-gallon peak flow plus extra storage of about 1,000 gallons to allow for overloads or breakdowns. If extra storage is not provided, the alarm switch should be wired parallel to the time switch to activate a drawdown and alarm in overflow situations. A timer/level-control combination can be set to pump 250-gallon doses at 12-hour intervals, or 14 cycles a week for a total of 3,500 gallons. Timer/level-control combinations also can help balance daily peak loads.

### *Description*

The standard components for the timer/level-control combination are a 24-hour time switch adjustable to 30- to 60-second intervals and two mercury level-control floats with a relay. The relay may be installed in a control panel or contained within a level-control float as described in Chapter 2. Other level-control combinations may vary in capability. In addition, a high water alarm must be installed. The high water alarm switch may be wired parallel to the time switch through a relay. This will allow for an alarm signal and an emergency drawdown simultaneously. The system operator is made aware of the problem, and the pumping chamber has less danger of overflowing. A larger pumping chamber is needed to accommodate extra flow if this circuitry is not used.

The dosing pump is activated when it receives signals from the time switch and level-controls. The time switch doses the field at predetermined intervals to spread out shock loads. The level-controls ensure that the tank will not be emptied below a cer-

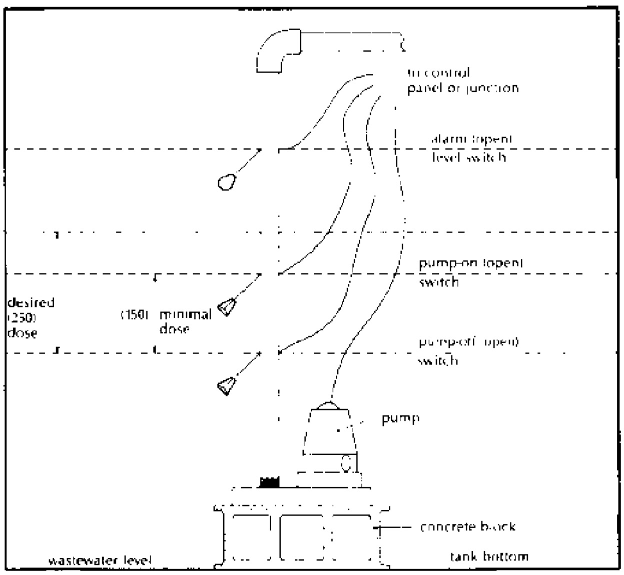



**Figure 4-1a:** *condition = normal operation*
*time switch = open*
*result = no cycle*

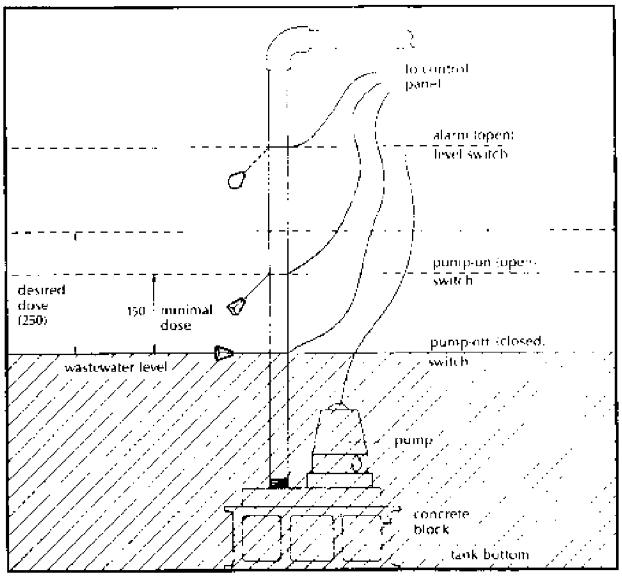



**Figure 4-1b:** *condition = normal operation*
*time switch = closed*
*result = no cycle*

tain point and guarantee a minimal dose. The lower level-control is positioned to protect the pump from exposure to the atmosphere or activation without wastewater present. If a timer alone were used, the pump would run even if the tank were empty, which would shorten the life of the pump. Thus, a level-control is installed above the pump to shut off the control system when the wastewater in the tank gets too low. If the tank fills faster than it is emptied by the timer cycles, the wastewater will rise until the high water alarm is activated.

### *Time switch*

The time switch must be adjustable for the time and length of the switching operation. It should have a clock with at least a 12-hour cycle, and the length of the switching operation should be adjustable to 30- to 60-second intervals or less.

Three mechanical time switches have been tested and found satisfactory. Two of these must be used in conjunction with each other. The third is used singularly. Two time switches, one with a long-cycle clock and the other with a short-cycle clock, are wired together. The long-cycle clock has a 24-hour cycle adjustable to 15-minute intervals. It is wired to activate the short-cycle clock which has a 30-minute cycle that is adjustable to 15-second intervals. This time switch activates the pump. The third time switch contains long- and short-cycle clocks in the same unit. These devices are described in more detail in Appendix II. Inexpensive, microelectric time switches are also becoming available, and these may be more versatile than mechanical time switches.

### *Level-controls*

Double-float level-controls, differential floats, or electromagnetic level-controls (Chapter 2) can be combined with the timer. All three types will halt the pump when wastewater is drawn down to the off position of the level-control switch.

The distance between the on and off positions of the level-controls should be equivalent to the drawdown required to pressurize the system. This minimum dosing volume assures good distribution throughout the field. With smaller volumes, the dosing area is not loaded uniformly. The minimum volume is equal to the volume of the manifold pipe plus five times the volume of the lateral pipes [described in the low-pressure pipe and mound manuals (Cogger et al., 1982a, 1982b)].

Two float level-controls with relays and differential level-controls will never activate the pump unless the wastewater level is at or above the on position, thus assuring a dose at least equivalent to the minimum volume. Because the electromagnetic level-control switch is not used with a relay, the minimum volume is not assured on drawdown cycles. Two electromagnetic switches may be installed in conjunction with a relay at greater expense. With properly calibrated controls, however, small doses will not occur often enough to affect the system.

### *Operation example*

Assume that the recreational facility system described in the earlier example has accumulated 2,000 gallons of wastewater in the pumping tank at the end of the weekend. The timer is calibrated to deliver two 250-gallon doses each day. This system will dose twice daily until the wastewater drops to the level-control. It will take about eight doses or four days to dose 2,000 gallons. Dosing will cease until enough wastewater accumulates to activate the level-controls.

If the same system accumulates 4,000 gallons of

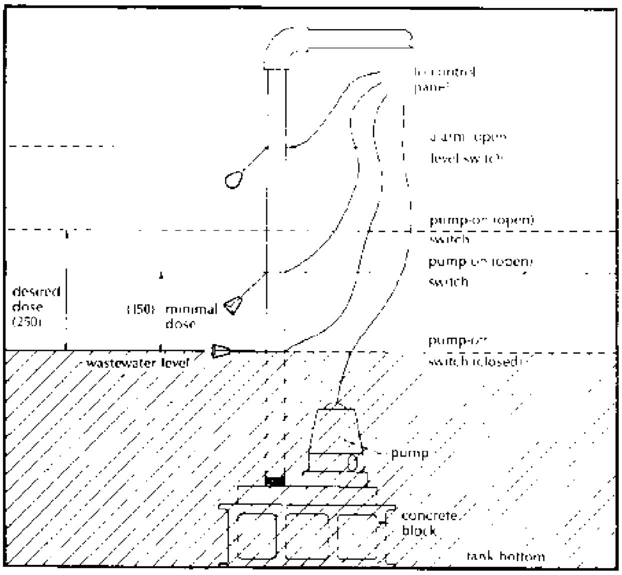



**Figure 4-1c:** *condition = normal operation*
*time switch = open*
*result = no cycle*

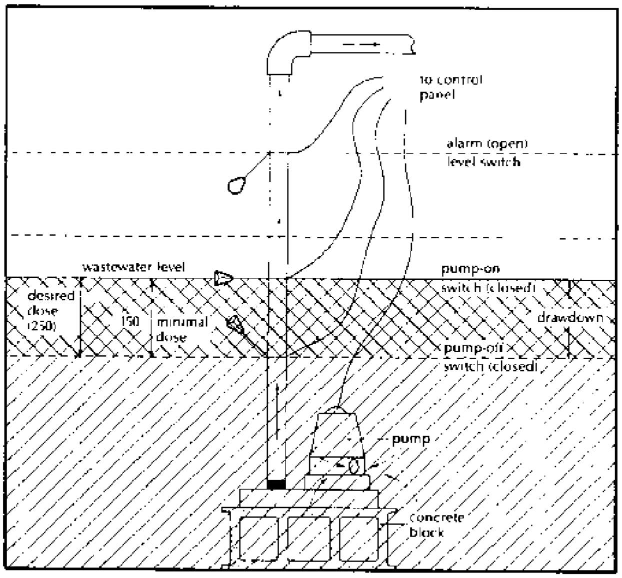



**Figure 4-1d:** *condition = normal operation*
*time switch = closed*
*result = minimal dose cycle*

wastewater by the end of the weekend, the two 250-gallon daily doses will not be enough to empty the tank in a week. If wastewater continues to accumulate faster than it is being dosed, the alarm will be activated, even though the pumping system is performing properly. The same result can occur if ground water infiltrates the septic tanks. If the absorption area can handle the extra load without exceeding its design capacity, the volume of each dose can be increased by adjusting the time. This will keep the wastewater level below the high-water alarm. If the field is already being loaded at design capacity, the load will need to be reduced through conservation measures or the field will need to be enlarged.

Sometimes the high-water alarm may sound even when the estimated wastewater load is not exceeded. This can occur when the actual dose delivered over the time period is smaller than the calculated one. Inefficient pumping or clogging of the lines can reduce the amount of wastewater dosed in each cycle. The alarm can be an early warning of these problems.

The control system that prevents daily shock loads works on the same principle and is illustrated in Figure 4-1.

### *Calibration*

Systems should be checked after installation to see if the timer is delivering the proper dose. The length of the dosing cycles should be adjusted to get good wastewater distribution over time without unnecessary alarm warnings.

### *Summary*

Timer/level-control combinations are useful when shock loads of wastewater are expected. They should be designed and installed with the following points in mind:

- The pumping tank must be large enough to accommodate the peak load and still have emergency storage, or the alarm switch must be wired parallel to the time switch.
- The level-controls should be set so that the off position is just above the pump.
- The drawdown distance between the level-controls should be equivalent to minimum dosing volume (manifold volume plus five times the lateral volume).
- The timer clock must be adjustable to provide the necessary time and duration of pumping cycles.

## Multiplex controls

A multiplex pump and control system can sequentially dose two or more absorption fields from one pumping chamber. Sometimes a pressure-dosed septic system must be designed using more than one absorption field. In North Carolina, all systems that have wastewater flows exceeding 3,000 gallons per day are required to have at least two absorption fields dosed by separate pumps or siphons. Dividing large systems into two or more smaller fields improves the distribution of effluent. Multiple fields should be installed on sloping lots where large elevation differences make good effluent distribution difficult to obtain from a single pump. In addition, space and soil restrictions on a site may necessitate dividing an absorption area into two or more separate fields.

Two basic types of multiplex controls are currently being used. One employs level-controls and an alternating switch; the second, level-controls and timers.

### *Level-controls with alternating switch*

This control consists of three level-control floats, one relay for each pump, and an alternating switching device. Two of the float switches turn the pumps on and off. The third switch acts as an alarm and also

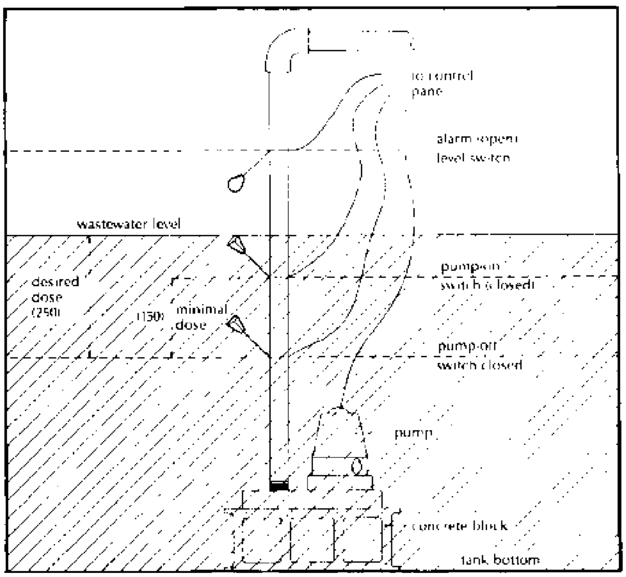



**Figure 4-1e:** *condition = normal operation*
*time switch = open*
*result = no cycle*

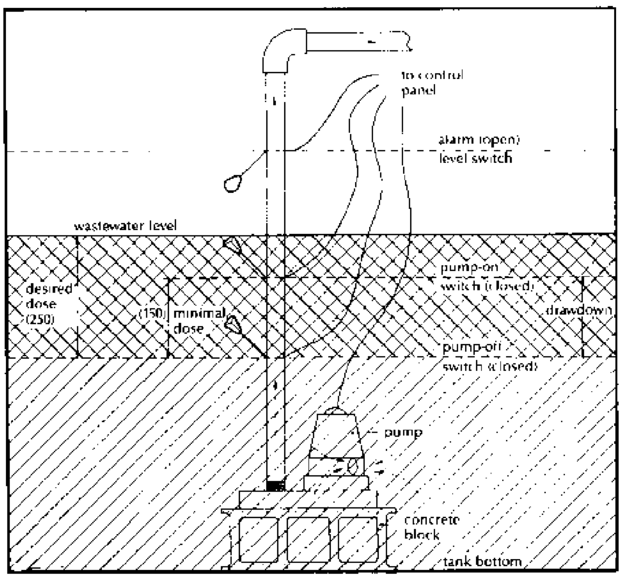



**Figure 4-1f:** *condition = normal operation*
*time switch = closed*
*result = cycle (desired dose)*

activates the pumps during an alarm situation. The alternating device switches the power from one pump to the next so that dosing cycles are alternated among fields. Each time the dosing circuit is energized, a small motor in the alternating device rotates a notched disc. The notches on the disc come in contact with snap-acting switches and regulate which pump is activated.

When wastewater accumulates in the pumping tank of a duplex system, the pumping begins when the second level-control activates a relay. This is the same as in a basic single-control system. The level-control also activates the alternating device, which switches the other relay into the circuit. This will activate the other pump on the next dosing cycle.

If wastewater rises to the level of the third and uppermost level-control due to a system malfunction, the control closes the alarm circuit. It will also activate any operational pumps. For example, if one pump is being energized but is not working, the wastewater will continue to rise until the alarm control is switched. This will signal an alarm and activate the second pump. The alarm will remain activated to warn the operator that the system needs immediate attention.

This system needs high capacity wiring for the alarm circuit since the alarm control also activates one or two pumps (Chapter 6). Also, the individual absorption fields must have similar loading rates since each field receives the same dose from the level-controls. These features are not available on all multiplex control panels. Some do not activate both pumps in an alarm situation.

### *Timer/level-controls*

This system employs two or more of the timer/level-control combinations described earlier. Each pump must be equipped with a complete timer/level-control system. The timers for each pump alternate wastewater doses among the absorption fields. For example, one timer may be set to dose at 9 a.m. and the second at 9 p.m. Since each pump has its own set of level-controls, it is possible to dose different amounts of wastewater to the individual fields. As with single timer/level-control combinations, the system must be checked and adjusted periodically to maintain proper dosing to all fields.

Both types of multiplex controls can be made to operate using one pump if the second pump fails. Repairs or replacement should be made immediately. Operating with one pump will result in overloading one of the absorption fields, which will cause costly damage to the system.

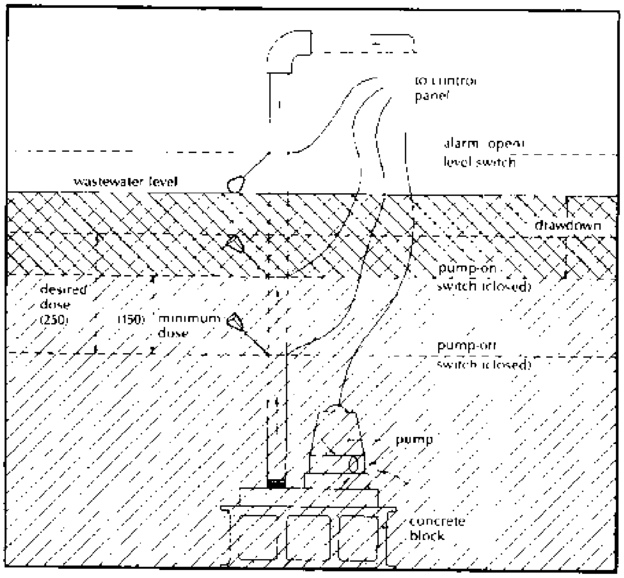


**Figure 4-1g:** *condition = shock load*
*time switch = closed*
*result = cycle (desired dose)*

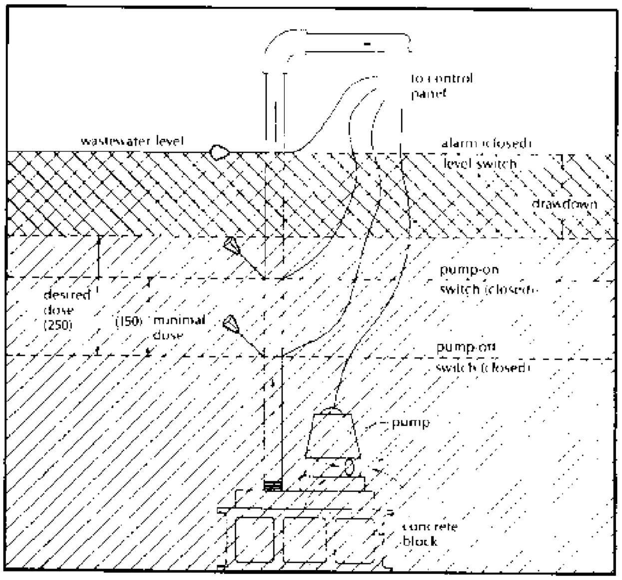


**Figure 4-1h:** *condition = continued shock load*
*time switch = closed*
*result = alarm cycle (desired dose)*

## CHAPTER 5

# Choosing the Right Control System and Components

Choosing electrical controls is an integral part of designing a pressure-dosed septic system. The controls must distribute effluent based on site and wastewater production characteristics, and associated hardware and wiring must be compatible. The basic type of control system can be selected using Figure 5-1 as a guide.

Once the system is chosen, the specific components must be selected, including level-controls, alarms and other hardware. Consult the charts in Appendix IV to determine adequate wire size and Appendix III to choose the proper enclosure for control panels.

A single level-control can be used for many household systems. Multiple fields and controls should be considered for large wastewater flows, for an absorption area on a steep slope, or for sites that require more than one field. In North Carolina, multiple fields are required when the design flow exceeds 3,000 gallons per day and should be considered where there is more than three feet of difference in elevation head over a sloping absorption area.

If shock loads of wastewater are expected, a timer/level-control combination should be used. For multiple field systems, timer/level-control combinations are useful where shock loads are expected or where the absorption fields are designed to take different amounts of effluent. Other multiple field systems can use level-controls with an alternating switch.

When choosing the specific components, the following basic criteria must be considered:

- compatibility with design requirements,
- reliability,
- accessibility for inspection and maintenance, and
- cost.

The components must be electrically and mechanically compatible with the control system. They must be designed specifically to operate in a sewage environment or be adequately protected from the environment. The level-controls must have an adjustable drawdown range, and the range of adjustment must be suitable for the job at hand. For example, a single, differential float level-control is inadequate for systems requiring a drawdown of less than 8 inches. But a double float or electromagnetic level-control will accomplish the job. Components and all connecting wiring have electrical specifications that must be compatible. For example, a level-control designed for an alarm is not suitable for switching a pump. Finally, components must fit into

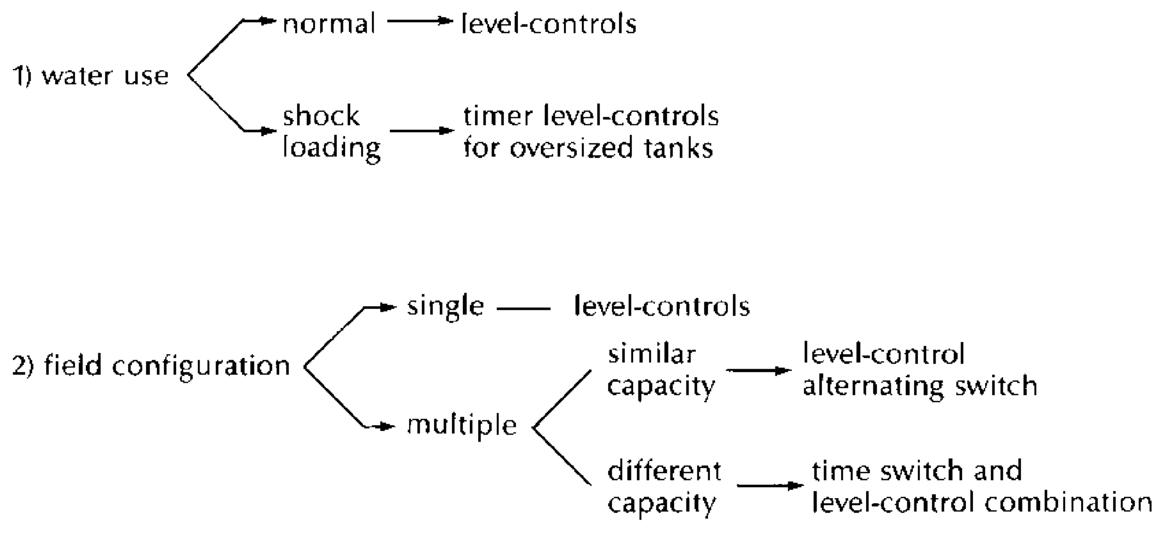



**Figure 5-1:** *choosing a control system*

the available space. For confined spaces, do not use a float level-control that swings over a wide radius for switching. Instead choose a control that operates vertically (such as an electromagnetic control).

Components must be reliable and have no obvious weak points such as loose gaskets or seals. Materials tested by Underwriters Laboratory (UL), an independent testing organization, can be used as a guide to quality. To be UL listed, materials must meet certain criteria. Continued observation of pressure-dosed septic systems should determine which types of components are the most reliable.

The pump and controls should be accessible for easy adjustment or removal. Locate an electrical disconnecting device within close visual proximity of the pumping chamber to prevent electrical injury during servicing pumps and controls. A manual override switch in control panels allows for pressure checks of the distribution system. For an accurate picture of total septic system performance, install electrical monitoring devices directly into the control circuit or wire electrical outlets to receive portable monitoring units (Fig. 3-1).

Finally, the cost of components should not be excessive. Initial and maintenance costs increase with complexity. The system should be designed as simple as possible, yet meet the criteria discussed.

# CHAPTER 6

# Proper Installation

Proper installation of an electrical control system requires special care and ensures that electrical components operate according to design specifications. Electrical components should be protected from their environment to reduce damage from corrosion and vandalism. Safety should be a major concern.

The four major considerations for installation are:

- components within the pumping chamber,
- electrical junctions,
- external components and wiring, and
- initial adjustment of components.

## Pumping chamber

The pumping chamber contains the submersible effluent pump(s) and usually the level-controls. The submersible pump should be designed to pump effluent and should meet the pressure and capacity requirements set during system design (see LPP and Mound manuals) (Cogger et al.; 1982a, b).

Regardless of the type of level-control used, the following principles apply for their installation:

- Level-controls should be accessible for adjustment, servicing or replacement.
- They should operate without entanglement in loose wires or other pumping chamber components. Some level-controls also need to be oriented in a certain direction. Make sure the top side is on top.
- Installation should be out of turbulent areas.
- The off switching point should allow for continual submersion of the effluent pump, which will prevent floating solids from clogging the pump impeller, will lessen oxidation of pump parts, and will ensure the pump is kept cool.
- Set the alarm sensing device for one or two days of wastewater storage capacity. This allows time to correct problems.
- Attach level-controls with hardware that doesn't corrode and permits adjustment (such as plastic ties or straps).
- Keep electrical junctions, other than those hermetically sealed by the manufacturer, outside the pumping chamber. (Length of electrical leads for the pump and level-controls should reach a point outside the pumping chamber).
- Before installation of any pumps or electrical control devices, check for electrical compatibility. In addition, check level-controls for their switching capability (NO, NC, switching arc, switch amperage and voltage). Pretesting level-controls can save future problems and inconveniences. Most can be tested outside the pumping chamber before installation.

## Electrical junctions

As previously stated, place electrical junctions outside the pumping chamber. Make electrical junctions in the following ways:

—hard wiring;
 a) junction box,
 b) underground splice (limited use),
 c) panel terminal,
—plug-in (limited use).

Hard wiring denotes connections of a permanent or semi-permanent nature as opposed to temporary, plug-in connections. Plastic junction boxes are an excellent choice for junctions exposed to weather. The lead wire of each component in the pumping chamber feeds through plastic conduit installed in the wall of the pumping chamber access riser (Fig. 6-1, 6-2 and 6-3). The electrical wires should feed through a watertight connector attached to the plastic conduit. The connector provides support and prevents passage of corrosive gases and moisture. In addition, a plug of duct seal should be molded into the conduit for added protection. Any space between the conduit and the access riser should be sealed to prevent surface water infiltration into the chamber. During installation of the conduit and placement of the junction, keep in mind that the wire may need to be replaced in the future. This will help determine the length of the conduit to the junction and the number of bends and offsets used.

Underground cable can be used for power and control lines to and from the pumping chamber, and underground junctions can be made. But underground cable and junctions are not recommended. If used, however, take care to ensure the junction is physically strong and protected from moisture. This type of junction increases future maintenance problems and encourages burial of component cables that are not designed for underground use. It also makes future troubleshooting more difficult.

If control panels or circuit panels are close to the pumping chamber, the junction can be made at the appropriate terminal strip or circuit breaker within the panels. Prior to making this junction, determine the feasibility of replacing the wiring without an in-line junction if repairs are needed (Fig. 6-4).

Plug-in junctions are frequently used, but they are not designed for continuous use in an outdoor en-

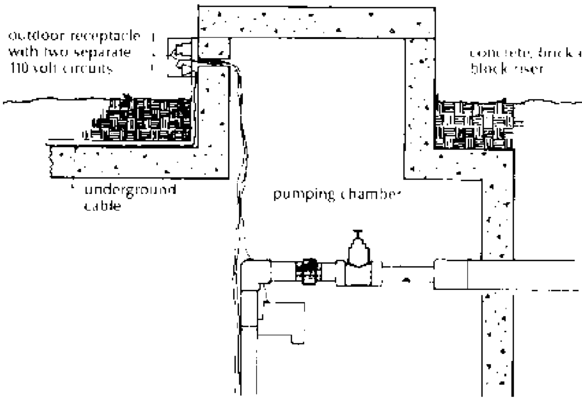



**Figure 6-1:** *the wall of the pumping chamber access riser*

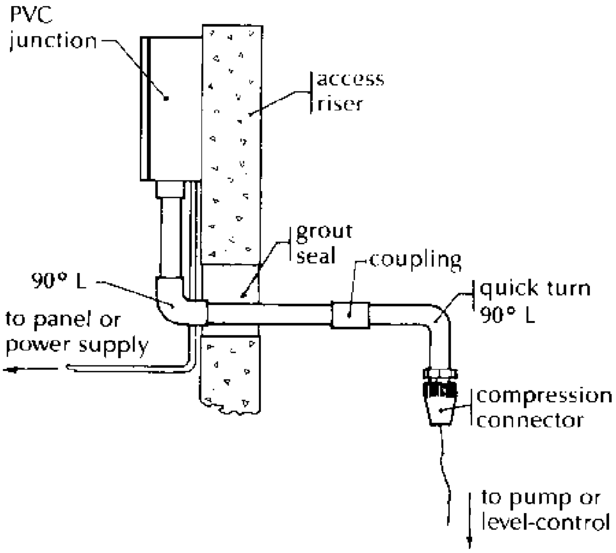



**Figure 6-2:** *installation using junction box*

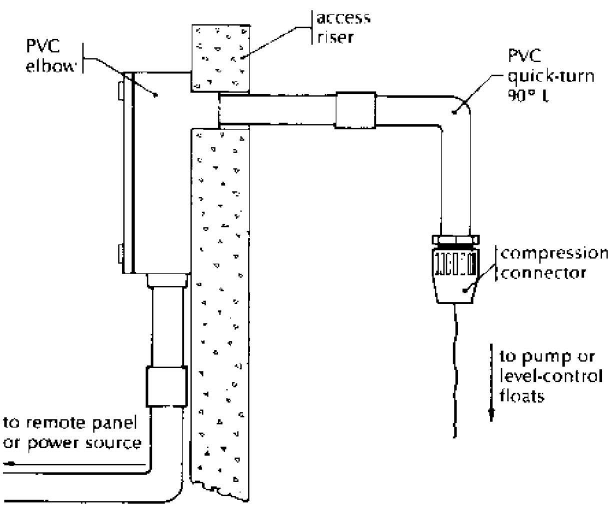



**Figure 6-3:** *installation using elbow for junction*

vironment. This approach, although convenient, leads to increased corrosion of the plug junction. Because it is a handy outlet, the unit may be unplugged to use electric yard appliances and not plugged in again. In addition, this junction is more susceptible to accidental disconnection or vandalism.

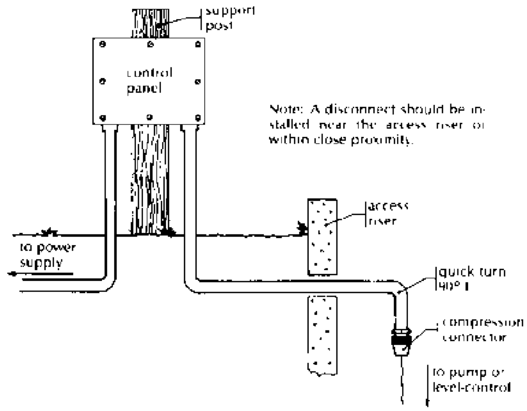



**Figure 6-4:** *installation using weatherproof control panel*

If a plug-in junction is used, a temporary service panel (such as those used for power during building construction) is an improvement over the standard outdoor receptacle. The NEMA 4 (National Electric Manufacturers' Association) enclosure protects the plug and usually has a latch for locking a cover over the plug. This approach is worth the modest extra cost (Fig. 6-5).

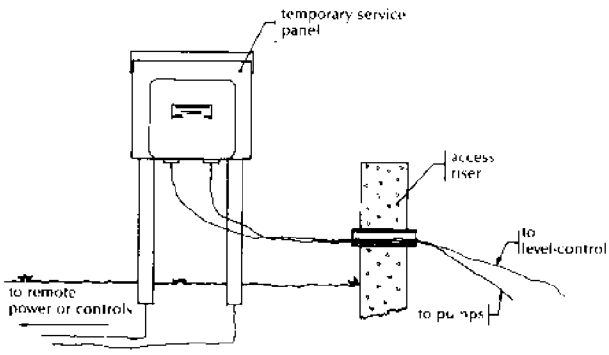



**Figure 6-5:** *installation using plug-in (temporary service panel)*

## External components and wiring

Placement of control panels, junctions, alarm devices and power supply in outbuildings, garages, basements or utility rooms provides the best protection. If these are unavailable or distance prohibits, use outdoor enclosures for panels and junctions. Choice of the proper enclosure (NEMA 1 for indoor use or NEMA 4 for outdoor use) is important for protecting components at reasonable costs (Appendix III). The indoor panels are ideal because they are unobtrusive and less susceptible to inadvertent disconnection and corrosion from weather. If panels or junctions are made outside, plastic enclosures are an excellent choice, especially in salty coastal air. Whatever the choice of location and materials, they should provide ease of access and compatibility with the environment. The tendency may be to buy the cheapest and the most readily available. In terms of future cost and maintenance, shop for the proper components and hardware, even if the initial cost is somewhat higher.

Power and control wires should be sized according to the distance from the power source and the amount of electrical demand (Appendix IV). Separate lines should be installed for the pump controls and the alarm. Many alarm situations arise due to faulty control circuits. If the alarm is an integral part of this circuit, it will not detect and indicate emergency situations arising from circuit failure.

## Initial adjustment

When the system is installed, adjust the pumping volume, time cycles (when necessary), and pressure head according to the design of the septic system. These should be checked and readjusted after the system begins operating to ensure they are working efficiently and within design criteria.

CHAPTER 7

# Inspection, Maintenance and Troubleshooting

Pressure-dosed systems need periodic checks due to their increased complexity compared with gravity systems. A six-month maintenance interval is desirable. Immediately after installation, systems require frequent inspection for fine adjustments and assessment. During maintenance checks, a number of components should be inspected, particularly the electrical control system. The inspection and maintenance procedure can be divided into four areas:

- the absorption field,
- the pumping chamber,
- the distribution network, and
- the power supply and control circuits.

A step-by-step guide list to inspection and maintenance follows. This includes an approach that has proven effective and covers many problems that may occur. Each system is unique and requires individual consideration. There is overlap in inspection points, providing for checks and double-checks.

## Guide list to inspection and maintenance

**I. Note the following changes in the absorption field.**

A. Standing water, soft spots, sudden changes in vegetation color and type.

B. Possible leakage around clean-out caps; breaks of the distribution laterals, turn-ups and manifold.

C. Surrounding drainage trenches and their possible influence on absorption field and pumping chamber.

D. Smells of stagnation or sewage.

E. Signs of unusual traffic on the absorption field. Common offenders are heavy lawn and garden equipment, livestock, pets, motorbikes, automobiles and people.

F. New construction and its potential for future problems through such things as parking lots, roads, drainage trenches, water mains, etc.

G. Blow-out holes in the soil. This may occur if the distribution laterals are improperly drilled or installed, if severe clogging has occurred, if the water table has been near the surface, or if a line is broken.

**II. In the pumping chamber notice the following.**

A. Wastewater level and its distance from the level-control switches and alarm switch.

B. Characteristics of the wastewater:
   1. Unusual amounts of grease;
   2. Unusual amounts of solids, both suspended and on the chamber bottom;
   3. Color as influenced by groundwater or surface water infiltration into the chamber;
   4. Smells of solvents that may affect wastewater treatment.

C. Free movement of level-controls and their secure attachment.

D. Possible wire fatigue at stress points of level-controls and the degradation of the controls and associated hardware.

E. Build up of solids on floats or displacement weights. Regardless of the use of sanitary T's, baffles and multiple chambers, solids are always a potential problem.

F. Exposure of pump at low water level. Level-controls should be adjusted so that the pump will remain submerged.

G. Proper seal of access riser to the pump chamber.

H. Proper seal around pipes through the walls of the pump chamber.

**III. If adequate waste water is present, check the distribution network for the following.**

A. Remove end caps of lateral lines, (may require the use of large channel lock pliers or pipe wrenches) and note any solids in cap and turn-ups.

B. Attach a length of PVC pipe with the appropriate adapter to the turn-up. (Five feet of clear 1¼ inch PVC with a male adapter on one end and a female adapter on the other is compatible and works well with most systems) (Fig. 7-1).

C. Activate the pump in one of the following ways:
   1. Manual override on the control panel (if one is present);
   2. Manually closing level-control switch by lifting float or weights;
   3. Bypassing switch plug of plug-in junction;
   4. Bridge terminals of control panel with alligator clips attached to insulated wire sized to handle load. *Use extreme caution to avoid electrical shock.*

D. Open the gate valve to clear any possible solid build up. Allow plenty of time for the distribution network to fill with wastewater before adjusting gate valve for pressure head. Entrapped air will cause erratic changes in apparent pressure head.

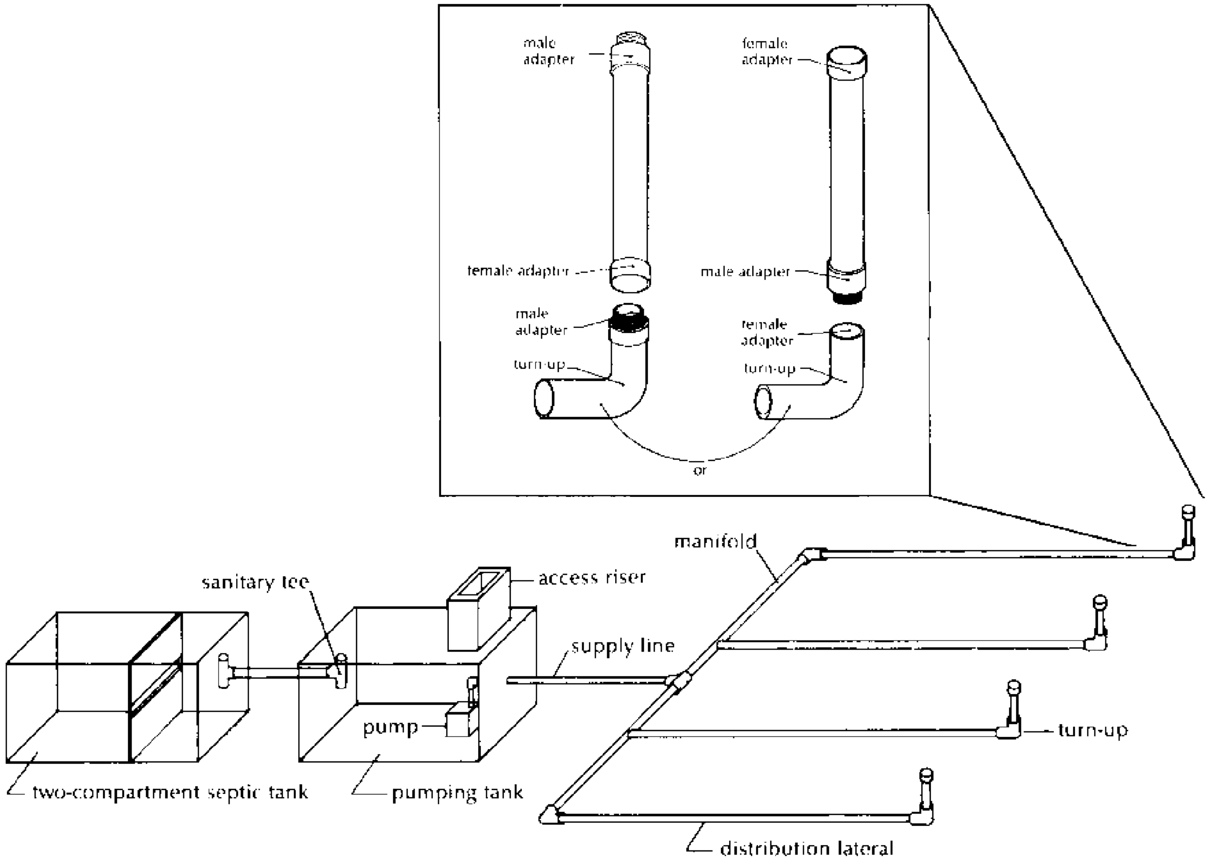



**Figure 7-1:** *pressure head check at turn-up of distribution lateral*

E. As the system stabilizes, close the gate valve until the water in the attached pressure check pipe is at the desired level (usually 2 to 4 feet). Be sure to account for the distance the lateral is beneath the ground.

F. Note the color and the amount of solids in the pressure check pipes as an indicator of excessive solid accumulation. It is helpful to have several pressure-check pipes attached so you can compare color of wastewater among lateral lines.

G. When the pump is deactivated, note the time required for water to drop in pressure check pipes. (Sluggish response may be an indication of clogging within the distribution lateral or its trench).

H. Note the amount of wastewater that drains back into the pumping chamber. An excessive amount of effluent draining back may indicate clogged trenches or a malfunctioning check valve. A slow continued drop in effluent level after the pump shuts off indicates siphoning into the absorption field that will result in overloading the field.

**IV. Examine the power supply and control circuit(s)**

A. Check the control float(s)—level-control devices—for:
   1. Entanglement or obstructed movement.
      a. Electromagnetic switches may require adjustment of spring mechanism. This is indicated if the switch stops the pumping cycle prematurely and the amount of effluent pumped is less than normal.
      b. Mercury switches may increase their switching differential angle with extended use. This is indicated if the amount of effluent pumped is greater than normal.

B. Check control panels for loose wires, moisture seepage or damage due to vandalism.

Troubleshooting of the electrical and mechanical components of a pressure-dosed system usually involves a systematic evaluation, starting with the simplest and moving to the most complex. The majority of problems tend to be simple, requiring only close visual inspection to detect. A simple voltage tester is sufficient to handle many problems, but a volt-ohm meter may be necessary for evaluation of some situations, especially control panels. The following are electrical and mechanical problems that may be encountered. Use a systematic approach for evaluation.

C. Level-controls:
   1. Improper capacity of switch (Example: a low amperage switch used in high amperage apWpliction). Mercury switches will sizzle and possibly explode. Contacts of push button switches will burn.

2. Mercury switches may become fixed in a closed position due to mercury adhesion to the contacts. Correct by shaking the switch down as you would a thermometer.

D. Submersible effluent pump:
   1. Solids may collect on impeller and decrease pumping efficiency or stop movement entirely.
   2. Pump housing may leak and expose electrical junction to moisture and/or gases.
   3. Faculty switching may cause the pump to operate beyond its design and cause motor damage.
   4. Surface water infiltration into the pumping chamber or siphoning from the absorption field may cause a pump to operate beyond its normal capacity and damage the electrical motor.
   5. Controls may be improperly wired.
   6. Lightning may strike in the vicinity of the pumping chamber and damage the pump.

E. Control panels:
   1. Circuit breakers may "trip," especially when ground fault circuit interrupters are used. Ground fault breakers operate at very low current and respond within a short time to circuitry failures.
   2. Fuses within panel may blow.
   3. Contacts of switches or relays may burn.
   4. Coil of relays may burn (become discolored).
   5. Improper wiring.
   6. Use volt-olm meter to check the various components of the panel. Manufacturer should provide resistance ratings and proper olm-meter settings.

F. Faulty junctions.
   1. Loose wires.
   2. Moisture seepage.
   3. Oxidation of aluminum wires.

G. Electrical control and supply wires:
   1. Break due to excavation or landscaping.
   2. Improper size of wire used for electrical requirements.
   3. Wire may not be rated for underground use and its insulation may permit moisture to short the circuit.
   4. Improper underground splice.
   5. Underground short may not become evident until rainfall occurs.

**V. Setting and checking drawdown capabilities.**

A. Determine number of gallons to be dosed according to system design (LPP Manual).
   1. Minimal dose—volume of supply manifolds plus five times the volume of laterals (LPP manual).
   2. Maximum dose—based on daily wastewater production and system design.

B. Must observe a normal dosing cycle.
   1. Control panels or timers can be overriden if present.
   2. Float switches may be physically moved to activate cycle.
   3. Ideally water should be added to the pumping chamber until float switch(es) activate.

**VI. Miscellaneous maintenance techniques.**

A. Use cam-lever couplings and drainage hose to purge the system.
   1. Hose is adapted to laterals with cam-level couplings.
   2. Opposite end of hose is placed within the pumping chamber containing the dosing pump.
   3. Wastewater is pumped into the laterals through the drainage hose and back to the pumping chamber. The wastewater is recirculated. It avoids effluent on the absorption field while cleaning out lines.

B. Use mobile impulse counters and elapsed time indicators (see previous description). These provide accurate measure of drawdown and indicate potential maintenance problems. (Example: Detects groundwater infiltration into pumping chamber and excessive wastewater production by system owner).

C. Use pressure gauges on lateral lines and pump to determine system operation.
   1. Clogged lateral line holes will give higher pressure reading.
   2. Obstructions in laterals will give lower readings.
   3. Pump obstructions or damage will give lower readings.

# APPENDIX I

# Details of Level-Control Operation

## Electromagnetic control

The electromagnetic switch assembly, spring adjustment mechanism and weight assembly of a typical electromagnetic level-control are described below.

The electromagnetic switch assembly is made of a two-part housing containing the switching mechanism. This consists of a basic microswitch with a lever actuator. A ceramic magnet attaches to one end of the lever. The other end of the lever attaches to the switch body where it pivots up or down. The microswitch is wired to NO for pressure dosing pump down or NC for tank filling pump-up operations.

The spring adjustment mechanism consists of a circular plastic rod, a stainless magnet follower, a spring and a spring adjustment bushing. The plastic rod is encircled by the spring, and the magnet follower is attached to the top of the rod. The magnetic follower is held in place by a spring-and-screw attachment. It allows limited movement of the weight assembly without full attraction of the magnet and subsequent switching. The spring-adjustment bushing is held to the lower end of the rod by a plastic nut that also attaches to the weight assembly.

The spring moves up and down the rod until it is compressed, one end against the circular platform and the other against the spring adjustment bushing. Changes in the compression on the spring (through movement of the adjustment bushing) controls the balance of force between the weight assembly and the attraction between the magnet on the microswitch and the magnet follower. This adjustment controls the sensitivity of switching and is the key to accurate operation of the electromagnetic control. The adjustment is made by the manufacturer at the factory, but preinstallation and six-month maintenance checks are recommended.

The weight assembly consists of two plastic displacement weights threaded through their centers onto a nylon support cable (Fig. 2-5). The weights are cylindrical with tapered tops to reduce the accumulation of solids on their surface. Accumulation of solids alters the sensitivity of switching by adding weight to the assembly. This can be a problem in pumping chambers containing high levels of suspended solids.

The displacement weights are adjusted up or down the support cable by moving a set screw on each weight into the support cable channel. Adjustment of the distance between the weights controls pumping distance and pumping volume. The bottom weight position determines the off position and the upper weight the on position. After the pumping volume distance is set, excess support cable must be removed to prevent the accumulation of solids and subsequent weight gain and switching variation.

## Operation

As the wastewater level rises, the lower displacement weight is submerged and the force is reduced on the spring adjustment mechanism. The water level rises until the upper weight is half submerged. Then, the force from the spring adjustment mechanism is reduced so much that the magnetic follower moves up and creates an attractive force with the ceramic magnet. The magnet pivots downward, and the switch is closed. This activates the pumping cycle. Pump-down continues until half of the lower weight is out of the water and the force on the spring assembly breaks the magnet and magnet-follower attraction. This causes the microswitch to be deenergized.

If the switch is wired for pump-up, the operation is reversed. When both weights are out of the water and the electromagnetic connection is open, the NC switch will signal the tank to fill by a remote pump. If both weights are submerged, the electromagnetic connection will close and the NC switch will open, signaling the end of operation. Changing wiring from NO to NC and vice versa is a simple procedure. It involves changing the connection of one wire from one terminal of the microswitch to another.

## Float level-control

### *Mercury switch specifications*

Mercury switches that have a moderate to small current rating (1 to 5 amperes) use a mercury-to-dry-metal contact. When the switch tilts, a mercury pool makes direct contact with the alloy metal of the electrode. This design will not handle the heating and arcing that is present with high electric loads. Using this type of switch in a high load situation will "sizzle" the mercury pool and cause switch malfunction and possible explosion. Level-control floats that contain this type of mercury switch are used in alarm controls or as pilots in the control system.

Mercury-to-wetted-metal contacts are used for higher load applications and for increases in differential angle. The electrodes are coated with a thin adherent film of mercury that improves the current carrying capacity and reduces arcing tendencies in high load applications up to 20 amperes. Level-control floats that contain this type of switch control switching of effluent pumps.

Mercury-to-mercury contacts are used for high current ratings, for a further increase in differential angle, and in situations where contact bounce is a potential problem. Two pools of mercury separated by a barrier join when the switch is tilted, thus making the contact. The contact breaks when the switch is tilted in the opposite direction. Some switches do not use a barrier, but the mercury pools flow together and apart again according to the shape of the glass enclosure. This type of switch can handle heavy arcing and its associated heat. They are used in float switches that operate singly rather than in pairs. Increased differential angle and decreased contact bounce make this possible.

*Plastic float construction*

The most common float shapes are cannister, disk, cone, pear and triangulated-pear. The floats are weighted to give added stability and to ensure proper orientation. If a float has a top and bottom side, its shape and weight distribution should ensure that it orients properly cycle after cycle. This type of float is normally marked to distinguish its upper and lower sides. Disk-shaped and triangulated-pear floats will malfunction if improperly oriented. If properly installed and oriented out of a turbulent area, they will function accurately. Cannister-shaped floats tend to roll and rock. They usually contain an omnidirectional mercury switch to counter this. The triangulated-pear float is designed for the most stability. This float shape often contains differential mercury switches.

Regardless of float shape and type of switch, turbulence is always a potential problem. All float shapes can be affected by turbulence and give short cycling. It is the combination of shape, material and switching mechanism that determines float effectiveness.

## APPENDIX II

# Time Switch Devices

A program time switch with fixed trippers, provides up to 96 on-off operations every 24 hours in 15-minute increments. It is rated at 20 amps, 125-480 VAC, 1 horsepower at 250 VAC; ½ horsepower at 125 VAC. This rating makes it compatible with most submersible effluent pumps used in pressure-dosed systems. The trippers are permanently attached. They push in for cycle activation and pull out for between cycle spacing. When the first tripper is pushed in, it activates the dosing pump for 16 to 20 minutes. Each additional tripper lengthens the activation time by 15 minutes. When the first tripper pushes out, the pump turns off for 10 to 14 minutes. Each additional tripper lengthens the off time by 15 minutes. A manual override switch aides in system maintenance checks. This time switch is best suited for recirculating sand filters, lift station pump control or activating another time switch.

The second time switch provides up to 12 on-off operations every 24 hours. The length of cycle is adjustable to 30 seconds and 24½ minutes. It is rated at 40 amps, 2 horsepower at 120 VAC. The added control over cycle time and the heavier duty contacts make this timer more versatile than the first. Its capacity for 1 to 12 operations daily creates a minimum off time of two hours. This is usually suitable for pressure-dosed system control. The time switch has two time dials, a 24-hour time dial and a 27½-minute time dial. They are mounted on a common shaft coming from the clock motor. The 27½-minute dial is mounted on top of the 24-hour dial. Screw-in time pins are attached to the 24-hour dial to activate the time of day of the cycle. The 27½-minute dial is graduated in 30-second intervals with an adjustable pointer to set length of cycle. This time switch and the one previously described are enclosed in NEMA 1 indoor cases. The manufacturer of the timer/level-control combination provides a NEMA 4 enclosure for installation of the timer, relay, and optional switch overrides.

## Description of Time Delay Relay (TDR)

A TDR is a type of electromagnetic relay. It receives a signal from the controller (the level switch). Upon activation, the TDR controls the flow of electricity to the load (the effluent pump), pausing after the relay coil is energized. The pause may be controlled by three devices: the dashpot, the copper ring and bimetallic strip.

With the dashpot device, the delay is determined by the amount of time it takes to move a given amount of air or liquid through a small hole in the plunger core. The copper ring, which encircles the magnetic core or pole piece, slows the increase in rate of change of magnetic flux of the core. The delay period is determined by size and position of the copper ring. The third relay uses the thermal principles of differential expansion and contraction of a bimetallic strip. Structure and material of the strip determine the length of time delay.

## APPENDIX III

# Types of Control Enclosures

| Enclosure | Explanation |
|---|---|
| NEMA Type 1<br>General Purpose | To prevent accidental contact of enclosed apparatus. Suitable for application indoors where not exposed to unusual service conditions. |
| NEMA Type 2<br>Driptight | To prevent accidental contact, and in addition, to exclude falling moisture or dirt. |
| NEMA Type 3<br>Weatherproof<br>(Weather Resistant) | Protects against specified weather hazards.<br>Suitable for use outdoors. |
| NEMA Type 3R<br>Raintight | Protects against entrance of water from a beating rain. Suitable for general outdoor application not requiring sleetproof. |
| NEMA Type 4<br>Watertight | Designed to exclude water applied in form of hose stream. To protect against stream of water during cleaning operation, etc. |
| NEMA Type 4X<br>Corrosion Resistant | Designed to exclude water supplied in form of hose stream and used in areas where serious corrosion problem exists. |
| NEMA Type 5<br>Dust Tight | Constructed so that dust will not enter enclosed case.<br>Being replaced in some equipment by NEMA 12 Types. |
| NEMA Type 6 | Intended to permit enclosed apparatus to be operated successfully when submerged in water under specified pressure and time. |
| NEMA Type 7<br>Hazardous Locations<br>Class I—Air Break | Designed to meet application requirements of National Electrical Code for Class I hazardous locations (explosive atmospheres).<br>Circuit interruption occurs in air. |
| NEMA Type 8<br>Hazardous Locations<br>A, B, C or D<br>Class II—Oil Immersed | Identical to Type 7 above, except the apparatus is immersed in oil. |
| NEMA Type 9<br>Hazardous Locations<br>E, F or G Class II | Designed to meet application requirements of National Electrical Code for Class II hazardous locations (combustible dusts, etc.). |
| NEMA Type 10<br>Bureau of Mines<br>Permissible | Meets requirements of U.S. Bureau of Mines.<br>Suitable for use in coal mines. |
| NEMA Type 11<br>Acid & Fume Resistant<br>Oil Immersed | Provides oil immersion of apparatus such that it is suitable for application where equipment is subject to acid or other corrosive fumes. |
| NEMA Type 12<br>Industrial Use | For use in those industries where it is desired to exclude dust, lint, fibers and flyings, or oil or coolant seepage. |

*(Courtesy of Putnam Water Guard)*

## APPENDIX IV

# Adequate Wire Sizes of Weatherproof Copper Wire

| Load Amperes | Distance | Recommended Wire Size |
|---|---|---|
| Up to 25 amps<br>120 volts | Up to 50 feet<br>50 to 80 feet<br>80 to 125 feet | #10<br>#8<br>#6 |
| 20 to 30 amps<br>240 volts | Up to 80 feet<br>80 to 125 feet<br>125 to 200 feet<br>200 to 350 feet | #10<br>#8<br>#6<br>#4 |
| 30 to 50 amps<br>240 volts | Up to 80 feet<br>80 to 125 feet<br>125 to 200 feet<br>200 to 300 feet<br>300 to 400 feet | #8<br>#6<br>#4<br>#2<br>#1 |

Sizes are recommended to reduce voltage drop to a minimum.

# Ampacities of Copper Wires

| | Type RHW | Type TW,R | Type RHW | Type TW,R | |
|---|---|---|---|---|---|
| Wire Size | In Conduit or Cable | | In Free Air | | Weatherproof Wire |
| 14 | 15 | 15 | 20 | 20 | 30 |
| 12 | 20 | 20 | 25 | 25 | 40 |
| 10 | 30 | 30 | 40 | 40 | 55 |
| 8 | 45 | 40 | 65 | 55 | 70 |
| 6 | 65 | 55 | 95 | 80 | 100 |
| 4 | 85 | 70 | 125 | 105 | 130 |
| 3 | 100 | 80 | 145 | 120 | 150 |
| 2 | 115 | 95 | 170 | 140 | 175 |
| 1 | 130 | 110 | 195 | 165 | 205 |
| 0 | 150 | 125 | 230 | 195 | 235 |
| 00 | 175 | 145 | 265 | 225 | 275 |
| 000 | 200 | 165 | 310 | 260 | 320 |

Adapted from Sears Roebuck Electrical Wiring Handbook.

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