LeakAlertor™ Technical Reference Guide (REV-D)

NOTE: This guide has been written to give water utility and industry experts an overview of the actual operation and methodology the LeakAlertor employs in order to correctly identify various types of toilet leaks. *If you do not wish to read this overview, please skip to the "Key Points" section at the end of this booklet, which covers the main technical points of the product*

Introduction

One of the most critical design objectives for the LeakAlertor was simplicity of installation and use. Achieving that objective without any user setup or calibration required developing a unique sensor technology and a correspondingly complex mathematical process, which would allow the product to be placed on virtually any tank and flapper based toilet. The combination of the sensor technology and mathematical process allows the LeakAlertor to be deployed on hundreds of different types of toilets using various fill valves, flappers, and fluctuations in water pressure (even on the same toilet), while simultaneously ignoring external noise, incidental bathroom "disturbances", and all kinds of non-toilet related interference.
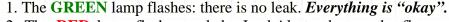
How Does It *Really* Work?

A leaking flapper will produce a drop in the water level inside the toilet tank, causing the fill valve float (or pressure sensor) to activate, which usually lasts several seconds. This phenomenon is often referred to as a "phantom flush". As the flapper continues to leak, this process repeats itself. When a fill valve action occurs (phantom flush or actual flush), water is forced into the tank at a rate which is a function of the water pressure, toilet feed-valve, and the ports of the fill valve itself. The pressurized water produces turbulence inside the tank, which in turn produces vibration. The LeakAlertor has been designed to specifically identify and isolate the vibration signature of a fill valve action and qualify it as a normal flush cycle, a refill action in response to a leaking flapper (or tank leak), or in a worst-case event, a wide-open flapper or flush valve.

Because every toilet's vibration signature is different, the LeakAlertor must first "learn" its environment. After attaching the product to the toilet and pulling the battery activation tab, the user is instructed to flush the toilet. The LeakAlertor then mathematically models the toilet as a function of the vibration due to water turbulence, committing the "flush signature" to memory. The flush signature is used to help determine other toilet characteristics, such as whether or not the flapper is leaking (see the "Technology Options" section for other modeled and data logged characteristics). The modeled flush signature is also used to determine when an actual flush is taking place so that upon completion of the entire flush cycle[1], the user can be alerted. The various alerts are as defined on the next page.

1. The **GREEN** lamp flashes: there is no leak. *Everything is "okay".*
2. The **RED** lamp flashes and the LeakAlertor beeps: the flapper (or the toilet itself) is leaking OR the flush valve is wide-open. The more significant the problem, the greater the urgency of the alert. When a wide-open flapper is detected, the alert is constant until the problem is corrected. The longer a leak goes uncorrected, the more the urgency of the alert increases. **NOTE:** When the initial flush cycle has been detected after the user pulls the battery tab during installation, the **RED** lamp illuminates until the flush cycle has completed.
3. The **YELLOW** lamp flashes and a single beep is heard: the battery is low and needs to be replaced.

The LeakAlertor contains other capabilities that are important to know and understand by those facilitating the testing and evaluation process.

During installation, LeakAlertor employs the first flush to qualify the normal acoustic environment while continuing to model the environment through the detection of water turbulence and vibration. There may be circumstances when LeakAlertor is unable to qualify the acoustic environment. The user may fail to initiate the first flush during installation or some toilets may be extremely quiet, producing minimal vibration, due to a very quiet fill valve, low water pressure or both. In these instances LeakAlertor is designed to use certain preset variables and will attempt to learn the toilet characteristics over time. This may take several days; depending on what data is or isn't modeled when the unit is first installed, the mechanical operation, normal use of the toilet and any associated background noise. Extensive testing and actual field data has shown that in most instances, LeakAlertor will mathematically model the toilet and detects leaks in just a few hours, or overnight at most. *As long as the product is placed somewhere on the outside of the toilet tank and the battery pull-tab is removed, LeakAlertor will figure out what it needs to know in order to monitor the toilet for leaks.*

What are the parameters used to identify a leak? First, it's important to understand that a single phantom flush does not qualify as a leak[2]. The LeakAlertor is looking for both continuous and intermittent leaks. Rather than produce a "cry wolf" product that overreacts to possible extraneous noise, the device first looks to discount background noise such as fans, vibration due to HVAC systems, hair dryers, stereos, etc. Second, the mathematical modeling algorithms are very complex due to the extraordinarily high number of variables which must be taken into consideration. Statistically, most bathrooms will have "quiet" periods when they are not in use – those times are optimum for LeakAlertor to evaluate the toilet for leaks, so leaks are often qualified during the overnight or quiet periods. When a leak is identified, an internal software flag is set. At the conclusion of the flush cycle (when the toilet is subsequently flushed), the LeakAlertor will alert the user that it has identified a leak with the flashing **RED** lamp and by beeping, the urgency of which corresponding to the severity of the leak detected (or flash **GREEN** if everything is okay). Until the leak is fixed, the unit will continue to alert the user every time the toilet is flushed. After 500 phantom flushes, the LeakAlertor will beep and flash after each qualified phantom flush. However, when a wide-open flapper is detected, the LeakAlertor will begin to produce a continuous alarm until the problem is corrected. In those situations, the LeakAlertor waits until twice the normal flush duration before beginning to flash the **RED** lamp and beep.
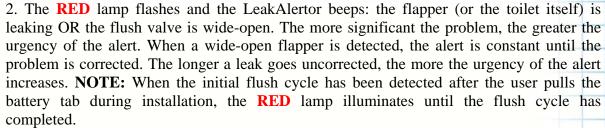
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[1] The definition "Entire Flush Cycle" (as pertains to the operation of the LeakAlertor) consists of pressing down the flush handle; the emptying and refilling of the toilet bowl; the refilling of the toilet tank by the fill valve; plus a slight delay after the fill valve float has terminated the entire flush cycle while the LeakAlertor processes information.

[2] Although it can be argued that a single phantom flush is certainly the result of a leak (water loss from the toilet tank), the LeakAlertor is designed to identify fill valve actions over intervals of time. An extremely slow leak may not cause enough fill valve actions within a given time frame in order for the LeakAlertor to qualify a leak. Empirical data suggests that leaks which constitute less than several gallons per day may not be detected by the LeakAlertor because of the long span between fill valve actions.

When the leak has been fixed, the LeakAlertor will automatically reset itself. This usually occurs overnight, but can take up to 24 hours to accomplish as several monitoring cycles in which no leaks are detected must first occur before the LeakAlertor will flash **GREEN.**

Technical Q&A

Will the LeakAlertor *always* detect a leak? Yes, with rare exceptions:

♦ A *properly* working fill valve has a "snap action" on-and-off operation, meaning the valve is either on or off. In situations where there is no detectable phantom flush, the LeakAlertor may fail to indicate the occurrence of a leak if the fill valve is not functioning correctly.

♦ If a leak is so minimal that it only produces a phantom flush once every 55 minutes or longer, the LeakAlertor may fail to see enough occurrences to qualify a leak worth alerting the user. Two things should be noted here: (1) the water loss is minimal in these instances, and (2), a slow leak will ultimately become a faster leak as the flapper continues to deteriorate or deform.

Does the LeakAlertor give some sort of indication after *every* flush? After every "qualified flush", the LeakAlertor will give the user a status indication. There are several exceptions:

♦ A "qualified flush" refers to the amount of time it takes for the entire flush cycle to occur, plus or minus 20%. If the user holds the flush handle down or should the water pressure drop substantially (changing the flush cycle time frame significantly), the flush might not be qualified.

♦ Some toilets are *very* quiet. The LeakAlertor will attempt to adjust its sensitivity in order to detect very quiet fill valve actions. This occurs as a function of several different factors. There are some rare instances in which the LeakAlertor is unable to detect certain super-quiet fill valves.

I held the flush handle down for several minutes to simulate a wide-open flapper and the alert started to sound, but when I released the handle the alert didn't stop immediately. Why not?

♦ When a wide-open flapper or flush valve has been detected, the alert does not stop until the tank refills and the fill valve has terminated water flow.

I held the flush handle down a little bit to try to simulate a leak, and I heard the phantom flush. But when I flushed the toilet, there was no indication that a leak was detected. Why not?

♦ Technically speaking, while you did simulate a leak, you did not simulate a leak that is characteristic of how a toilet normally leaks. In general, the LeakAlertor is looking to qualify leaks which are characterized by periodic fill valve operations (phantom flushes that occur over time), which is how a toilet normally tends to leak. Order our **Leak Simulation Kit** if you want to simulate an authentic toilet leak.

Can I use the same LeakAlertor on multiple toilets? Yes. Here's how:

♦ When switching toilets, remove the LeakAlertor battery and reinsert the battery tab (or make a battery tab out of an index card: it should be about 5/8" wide and 2" long; place it between the battery and the circuit board, with the end protruding through the slit on the enclosure). Install the LeakAlertor on the new toilet, pull the tab, and flush when instructed. It may be necessary to remove and replace the double-back tape on the base, which is readily available in retail stores.

Why isn't the beep louder?
Unlike smoke alarms which are designed to emit an ear-splitting sound, the LeakAlertor isn't a lifesaving device. It's assumed that some people, once alerted to the fact their toilet is leaking, will procrastinate in fixing the leak. The purpose is to alert them when they are nearby (after a flush) that their toilet is leaking, not create an unnecessary annoyance.

What affects the battery life? In normal operation, the LeakAlertor will operate for more than two years on its internal battery. However, a continuously leaking toilet or wide-open flapper that is not fixed will cause the unit to constantly beep and flash, decreasing the life of the battery.

Can users replace the battery themselves? Yes, and it only takes about a minute. Simple battery replacement instructions are included with the product, and the very common CR2032 lithium watch batteries are available at most retailers or can be ordered directly from *n^th Solutions*.

Key Points

⇒ Regardless of user competency or their following of the installation instructions, as long as the LeakAlertor is attached somewhere on the outside of the toilet tank **and** the battery activation tab is removed, it will "learn" what it needs to about the toilet and respond accordingly to leaks.

⇒ The LeakAlertor quickly detects wide-open flappers or flush valves and continues to sound an urgent alarm until the problem is corrected.

⇒ Depending upon the frequency of toilet use and nearby environmental disturbances, the LeakAlertor could take up to several days to identify a slow leak, although most leaks will be identified within several hours.

⇒ The LeakAlertor will automatically adjust itself and continuously monitor the toilet as it seeks to identify leaks and alert the user accordingly.

⇒ Once a leak has been detected and the user fixes the problem, the LeakAlertor will automatically reset itself within 24 hours.

Technology Options

♦ Non-volatile storage of complete water use profiles- including total number of flushes, amount of water wasted due to leaks and wide-open flappers- available for property management, hospitality and water utilities. No removal or connection to the products is necessary. Hand held non-contact electronic interrogators instantly secure the data

♦ Short-range telemetry for property management and hospitality, which allows remotely located receivers to receive and log "Report by Exception: leaks from tenant/guest toilets."

♦ Display Units: attached to the LeakAlertors by a short cable, these devices display all of the pertinent data and calculations made by the LeakAlertors in real time. Request the "LeakAlertor™ Data Display Unit" Technical Reference Guide for more information.

Contact Ernie Howard or Susan Springsteen for information on how *n^th Solutions* **LLC** can facilitate the administration of, and logistics for, pilot programs, customer service sales and/or giveaways, conservation programs, etc.

For technical questions email engineering@leakalertor.com
For marketing inquires contact Ernie Howard: ernie.howard@nth-solutions.com

n^th Solutions **LLC** 15 E Uwchlan Ave Ste 412, Exton, PA 19341 • 1-877-LEAKALERTOR
www.leakalertor.com

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