Battery Life in Water Communication Modules

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Table of Contents

Introduction

For water providers utilizing automated meter reading (AMR) technology or advanced metering infrastructure (AMI), battery longevity and the frequency of battery replacement in radio frequency (RF)-based endpoints are critical factors in maximizing the benefits of these systems. The cost of replacing batteries—especially the labor portion—can have a huge impact on the total cost of the AMR or AMI system. When comparing technologies, utilities need to consider the total lifecycle cost, *including* battery replacement, to gain a full understanding of the true AMR or AMI system costs.

The frequency of the transmission required by the selected meter data collection system is critical to battery life, whether it is a mobile AMR, fixed network AMI or hybrid (combination AMR/AMI) system. In designing AMR/AMI endpoint functionality, the laws of physics state:

The higher the output power and the greater the frequency of transmission, the shorter the battery life.

Designing for extended battery life increases the long-term performance of AMR/AMI systems and minimizes costs related to system maintenance and battery replacement. This paper discusses battery longevity for the 50W, 60W, 100W/100W+, and 200W series water communications modules. Itron's battery predictions are based on understanding the physics of failure, modeling, and lab test and field tests on functional units.

Battery Technology

Itron modules use two A cell Li-SOCl2 batteries in the 50W, 60W and 100W/100W+ ERT modules. The 200W series endpoints use a single D cell Li-SOCl2 battery. The 50W, 60W and 100W/100W+ ERT modules are used in Itron's 900 MHz handheld, mobile, and fixed network meter data collection solutions. 200W endpoints are used exclusively in the Itron 1.4 GHz water Fixed Network 2.5.

Determining Battery Life

Battery life is dependent on battery capacity, the meter module's operating specifications, and transmission frequency. Itron determines the average battery life using a combination of lab tests, modeling, and field monitoring.

Lab Testing Program

Battery failures can occur due to the following conditions:

- Capacity exhaustion, relative self-discharge, and voltage drop due to the operating conditions
- Integrity of the battery case holding the electrolyte and Li metal

To evaluate both physical and battery chemistry characteristics, Itron develops test models and conducts accelerated life tests to determine battery susceptibility to the above failure modes. These experiments include battery discharge under various conditions, impedance measurements, and micro-calorimetry experiments.

Itron then uses the lab results to verify the model assumptions and determine pertinent model parameters. Predictions made from the lab results are then tested using field data, following Itron's battery field monitoring program.

Field Testing Program

In 1997, Itron began a program to validate battery life design on gas ERT modules at several utilities. In this program, functional gas ERTs from six to eight utilities, which have been in the field for more than five years, are removed from the field. Various tests are conducted in-house on the batteries, including determining the remaining battery capacities. Consistent data is obtained from year to year for the various utilities. The field data helps Itron further develop and correlate the accelerated lab tests with the field. The field data also give credence to Itron's battery life predictions. Testing takes into account variables such as product type, battery type, location and climate, and the type of data collection technology used.

For more information on battery life in Itron gas ERT modules, see "The Proving Ground: Gas ERT Battery Performance" (Publication 100753WP-01).

Leveraging the data and methodology from the gas ERT module battery testing, Itron conducts water communication module field monitoring to improve the accuracy of battery life prediction models in water modules. Functional water communication modules—which have been used for more than five years—are removed from the field. Their batteries are tested to collect field data that Itron uses to develop and correlate accelerated lab tests. Through this program, Itron engineers new communication modules and matches them with the best type of research-proven batteries.

Wake-Up vs. Bubble-Up Mode

AMR/AMI endpoints operate in two basic modes: wake-up and bubble-up. Battery life varies significantly depending on the operating mode required by the utility.

Wake-Up Mode (50W-Series ERT modules only)

In wake-up mode, the ERT module transmits the meter reading only when it receives a "wake up" signal from a reading device that is within RF range. Typically, this is a handheld or mobile reading device. This approach conserves battery power, since the device only transmits when the meter reading device is within range of the unit. Sending a wake-up signal requires a license with the Federal Communications Commission (FCC). Wake-up mode allowed utilities to take advantage of a longer battery life.

Automatic Meter Reading in Wake-Up Mode

Bubble-Up Mode (50W, 60W, 100W, 100W+, and 200W Series)

In bubble-up mode, the meter reading is transmitted continuously within the module's frequency band. The advantage to this approach is that an FCC license is not required. This approach is optimally used with fixed network AMI systems for daily and hourly readings; however, bubble-up mode can also be used with other AMR meter data collection solutions. To support mobile AMR systems—where the vehicle drives at normal speeds—the meter-reading is transmitted every few seconds. These more frequent transmissions significantly shorten battery life. When users collect large amounts of interval data from the 100W or 100W+ ERT modules, collection results are more reliably acquired if users drive at slightly slower speeds.

Automatic Meter Reading in Bubble-Up Mode

Calculating Battery Life

Itron uses the following formula for calculating battery life:

$$Hours = \frac{Average\ battery\ capacity\ (in\ micro\ amp\ hours}{Average\ current\ consumed\ by\ circuit + self-discharge\ (in\ micro\ amps)}$$

(To convert hours to years, divide the answer by 8760, the number of hours in a year.)

50W Series

With its dual-mode operational capability, the 50W-series ERT module encodes accurate consumption and tamper information from the water meter and can be programmed to communicate with 900 MHz Itron meter reading technologies in either "wake-up" mode or "bubble-up" mode.

When the 50W and 50W-1 ERT modules were first introduced in 2001, the modules used two A-cell ER17/50 2750 mAh capacity Lithium batteries. In March 2002, Itron started using two higher-capacity 3300 mAh batteries in the 50W series ERT modules. By January 2003, all 50W series ERT modules were manufactured with 3300 mAh capacity batteries. When the module is used in wake-up mode, the battery life of the 50W series greatly exceeded the 20-year design life of the ERT module, for both 2750 and 3300 mAh capacity batteries, making battery replacement programs unnecessary.

For 50W series ERT modules used in bubble-up mode with 2750 mAh capacity batteries, the more frequent transmission of the ERT module resulted in an average estimated battery life of 10 years. With 3300 mAh capacity batteries (which are now used exclusively), the battery life of the 50W series in bubble-up mode resulted in a minimum of 10 years.

- Average battery capacity (wake-up) = 6.6 Ah
- Average battery capacity (bubble-up) = 6.6 Ah
- Average current consumed by the circuit during wake-up = 10 µA.
- Average current consumed by the circuit during bubble-up = 32 µA.
- Self-discharge of the battery pack, during wake-up conditions = 2.89 µA.
- Self-discharge of the battery pack, under bubble-up conditions = 10.54 µA.

To calculate battery life for the 50W series ERT modules used in wake-up mode, where the endpoint is read on a monthly basis:

$$Average\ battery\ life = \frac{(6.6\ x\ 10^6)}{(10 + 2.89)} / 8760 = 8.45\ years$$

To calculate battery life for the 50W series used in bubble-up mode, where the ERT transmits once every three seconds:

$$Average\ battery\ life = \frac{(6.6\ x\ 10^6)}{(32 + 10.54)} / 8760 = 17.71\ years$$

200W Series

The 200W series endpoints are designed specifically for use with the Itron water Fixed Network solution. The high-powered 1.4 GHz 200W endpoints deliver 1 watt of RF power, enabling utilities to optimize the use of concentrators (CCUs) in the network. Data logging allows for storage and retrieval of 35 days of hourly consumption information. 200W endpoints only operate in bubble-up mode.

- Average battery capacity = 16.5 Ah
- Average current consumed by the circuit during standby and bubble up = 54 µA.
- Self-discharge of the 'D' size battery, under these conditions = 38.7 µA.

$$Average\ battery\ life = \frac{(16.5\ x\ 10^6)}{(54 + 38.7)} / 8760 = 20.3\ years$$

60 Series

The compact 900 MHz 60W encoder and 60WP pulser ERT modules provide superior performance in harsh pit environments and require no field programming for easy, low-cost installation. Advanced leak, reverse-flow and tamper detection help utilities reduce O&M expenses and improve customer satisfaction. The 60 series only operates in bubble-up mode.

60W Encoder

- Average battery capacity = 7.3 Ah
- Average current consumed by the circuit during standby and bubble up = 30 µA.
- Self-discharge of the battery pack, under these conditions = 9.81 µA.

$$Average\ battery\ life = \frac{(7.3\ x\ 10^6)}{(30 + 9.81)} / 8760 = 20.93\ years$$

60WP Pulser

- Average battery capacity = 7.3 Ah.
- Average current consumed by the circuit during standby and bubble up = 38 µA.
- Self-discharge of the battery pack, under these conditions = 12.75 µA.

$$Average\ battery\ life = \frac{(7.3\ x\ 10^6)}{(38 + 12.75)} / 8760 = 16.42\ years$$

100W/100W+ Series

The advanced 100W and 100W+ ERT modules allow water utilities to capture large amounts of information to be used in many ways across the utility—from customer service to engineering; distribution planning to conservation; and field service to executive management. The 100W/100W+ provides the advanced functionality desired by utilities and Itron's proven product reliability for a low total cost of ownership. A single ERT module gives water utilities the flexibility to collect meter data in mobile, fixed network, and hybrid environments. 100W and 100W+ ERT modules are compatible with water meters from all leading manufacturers.

Battery Life calculation for a typical 100W or 100W+ encoder (Mobile/HH SCM/SCM+) (As shown below, various network versions have slightly different battery life for pulsers and encoders):

- Average battery capacity = 7.3 Ah.
- Average current consumed by the circuit during standby and bubble up = 26.30 µA.
- Self-discharge of the battery pack, under these conditions = 8.48 µA.

$$Average\ battery\ life = \frac{(7.3\ x\ 10^6)}{(26.3 + 8.48)} / 8760 = 23.96\ years$$

Battery Life Expectations in Bubble-Up Mode

Itron learned from the design and subsequent studies of the Itron 40G series gas ERT modules. We applied what we learned to develop batteries that provide even better performance for our newest meter modules which operate only in bubble-up mode. Bubble-up only modules include the 60W, 200W, 100W and 100W+ ERT modules.

	50W Series	60W Series	60WP Series	100W/100W+ Series*	200W Series
Average Battery Life	17.71 years	20.93 years	16.42 years	23.96 years	20.3 years
Collection Systems	Handheld, Mobile, Fixed Network 2.0	Handheld, Mobile Fixed, Network 2.0	Handheld, Mobile Fixed, Network 2.0	Encoder, Handheld/Mobile, SCM/SCM+	Water Fixed Network 2.5
ERT Module Design Life	20 years	20 years	20 years	20 years	20 years

**The battery life is different for various network applications with examples shown in the following Table. Values listed are based on a 25°(C) endpoint operating temperature.*

Type of ERT Module (100W+ Series)	ERT Module Reading Configuration	Average Current	Calculated Battery Life
Pulser with Leak Sensor	Secure Fixed Network mode (16 bit intervals) with SCM+	33.9 uA	18.46 years
Encoder with Leak Sensor	Secure Fixed Network Mode (16 bit intervals) with SCM+	28.0 uA	22.47 years

Field Testing program for Water Endpoints

Itron recently implemented the 60WP Field Program. The battery life data from the field fully supports the model prediction, which in turn, gives credence to the Itron's model predictions and test methodology. The following table shows some of the data from the field test program.

Utility/Product	Field Life (in years/ standard deviation)	Model Predictions (in years)
CoH/60WP	15.69/1.87	16.42
CoH/60WP	16.04/0.86	16.42
Aqua/60WP	15.03/0.843	16.42

As shown by the table data and taking component variations into account, the data substantiates the model predictions.

Battery Quality Program

Itron works continuously to achieve the maximum performance at the lowest cost. Batteries from our vendors undergo an exhaustive test program—in both standalone and installed states—before they are qualified for use in Itron products. Itron implements a battery quality program, testing approximately 30 batteries pulled from our production line (samples from all vendors) bi-monthly. Battery tests include short-term/long-term reliability and performance tests to ensure consistent battery performance.

Summary

Millions of customers continue to benefit from patented Itron products. Batteries used in Itron communication modules assure long product life to maximize your investment in Itron systems and minimize your operational costs. Itron is committed to our customers through our proven AMR/AMI technology that optimizes battery life and delivers the longest communication module battery-life in the industry.

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