



Accelerated Life Testing – PQube 3



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## PQube® 3 Power Quality and Energy Monitor: MTBF<sub>est</sub> = 87 600 hours (10 years)

1. **Summary conclusion:** PSL estimates the MTBF of the PQube 3 as 87 600 hours, or 10 years.
2. **Laboratory testing:** as part of our normal development cycle, PSL exposes PQubes to high and low temperature extremes and humidity extremes (beyond rating), direct lightning strikes (beyond rating), EFT (extremely fast transients, beyond rating), and voltages between test terminals and user terminals in excess of 1000% of ratings. No failures are permitted during these tests, so the results of these tests cannot be used to estimate MTBF.
3. **Accelerated life testing:** as of January 2017, PSL has maintained a fleet of 20 PQube 3's for 17 months, at a constant 65°C ambient (beyond spec), 24 hours per day. No functional failures have been observed during this test. Some cosmetic changes have taken place. With no failures, this test cannot be used to estimate MTBF, although it indicates that practical MTBF probably exceeds 28 years.
4. **Actual field experience:** as of January 2017, we have  $7.05 \times 10^6$  hours of field operations of the PQube 3, with 26 reported failures<sup>1</sup>. This is an observed MTBF of 271,000 hours, or 31 years.
5. **Engineering estimates of component life:** Based on calculated component life of the weakest component, PSL estimates the MTBF of the PQube 3 at 96,000 hours, or 11 years.

Analysis: The part in the PQube 3 at greatest risk for failure is the super-capacitor used for shutdown assist and temporary ride through. PSL recommends that its extended temperature range UPS module be used in any application that will see high temperatures. This UPS module replaces the function of the internal super-capacitor; therefore PSL calculates the risk for super-capacitor failure only for applications in controlled temperature environment, nominally 25°C ambient. Severity of the supercap end of life: at end of life of the component, the PQube 3 still operates and measures normally, but it has a very reduced ride through capability without UPS assistance. The PQube 3 has design margins that tolerate 3 lifetimes of degradation of the supercapacitor. The PQube 3 rarely discharges the supercapacitor, only during instrument power failures, and then only over the course of a few seconds. Our engineering judgement is that this rare discharge increases the lifetime by a factor of 2. The PQube 3 charges the supercapacitor to a voltage that corresponds to the manufacturer's acceptable temperature of 85°C, according to the supercap manufacturer. Using a nominal 20°C temperature rise over ambient gives 45°C at the capacitor, and the rule of thumb that reducing the temperature by 10°C temperature increases the lifetime by a factor of 2, we conclude that the useful life of the super-capacitor is  $1,000 \text{ hours} \times 2^4 \times 3 \times 2 = 96,000 \text{ hours}$ , or 11 years.

<sup>1</sup> These failures include hardware failures that were subsequently removed in design changes; random hardware failures; failures in ethernet hardware; firmware failures that required returning the PQube to the factory, a relatively small number of user errors (such as connecting 120VAC to 24V inputs), etc. These failures exclude simple firmware bugs that were corrected with in-the-field firmware upgrades. Both the number of hours and the number of failures exclude early-release PQube 3's from 2014-2015, which had no longer-supplied memories with a higher failure rate.