10

Reliability

Reliability and the related term, probability, are frequently misunderstood concepts. The manager who must evaluate alternate UPS systems may hear claims that a given manufacturer's system offers such great reliability that no problems will be seen until well into the next millennium.

This is not surprising as numbers can get tossed around quite casually. Depending upon the manufacturer, MTBF claims range from 15,000 hours (about two years) to over 2,000,000 hours (about 230 years). A manager evaluating one claim of 500,000 hours and another of 700,000 hours could ask, "Is this difference important? Do we really care whether my UPS breaks in fifty years or in seventy? What guarantees do we have? Do we believe any of these numbers? What do probability and reliability claims really mean?"

Probability is a mathematical statement of how likely a thing is to happen, usually over some defined time. Probabilities are expressed as a number from 0 to 1, with 0 representing an impossible event, and 1 representing an event certain to happen. For example, the probability of throwing a "3" with a fair die is 1/6. The probability of the sun rising in the morning (whether or not you see it) is 1.

MTBF is a statistic that was developed to provide a quantitative measure of how reliable a manufactured item will be. MTBF does not mean that a given item will absolutely last a given number of hours without breaking. In fact, there is no guarantee that any of the systems in question has, or ever will, run that many hours. Consequently, MTBF is nothing more than the result of adding up the total number of hours that all systems of a given kind have run, and dividing by the number of failures. Here is the equation:

$$MTBF = \frac{Total\ accumulated\ operational\ hours}{Total\ number\ of\ failures}$$

To illustrate, suppose that a manufacturer has shipped 100,000 clock radios and his products have been in use for 6 months (4,380 hours), except for 500 that have been returned for various reasons. We can call these returns 500 failures. By definition, the MTBF for this group is:

$$MTBF = \frac{100{,}000 \ X \ 4{,}380}{500} = 876{,}000 \ hours$$

It is obvious that none of the radios ran anywhere near 876,000 hours so what does that total mean? Looking at the problem in terms of the owner of a clock radio, his concern every night is, "What is the probability that my clock radio will fail between the time that I go to sleep, and the time that I want to get up?" Using MTBF data to estimate the answer, if the period of interest to the owner is eight hours (from bedtime to wake up time), and as long as this critical period is much shorter than the MTBF (less than 10 percent is a good guideline), an approximate relationship would be as follows:

$$Pf = \frac{t}{MTBF}$$

Where:

Pf is the probability of failure
t is the time of interest

Thus:

$$Pf = \frac{8 \ hours}{876{,}000} = 0.000009 \ (very \ small)$$

Thus, the owner of a single clock radio who pays attention to probabilities could reasonably relax and get a good night's sleep.

Of course, most of us are not that concerned about clock radio performance. A more practical concern for facility and/or data processing managers is how reliable a proposed UPS is going to be. With claimed MTBF's in the 500,000 hour range and up, this may seem an unlikely topic for concern.

Let's take a look by using a requirement of 3000 kVA with redundancy, (one extra module). For statics, we'll use 500 kVA modules, and for rotary, we'll use 1000 kVA modules.

Static Ups System

To evaluate the reliability of a static system, we need to know how many modules are in use and what the reliability of each module will be. We also need to decide how we want to look at reliability. It is common to look upon a UPS system, which includes a redundant module, and decide that if just one module breaks, there is no failure. Anyone who has had to put in emergency calls to a UPS vendor at three o'clock in the morning just might disagree with this notion. It is quite reasonable to decide that a failure anywhere is just that - a failure. The fact that the load was not dropped is a testimony to good planning, not a statement of UPS quality. Let's see how this revised thinking affects our results.

This 3,000 kVA system will need 3,000/500 + 1, or 7 modules total. The published data shows 150,000 hours MTBF assuming availability of bypass. In other words, the 150,000 hour claim does not count as a failure if the module transfers to bypass (raw utility). This is not the number we need for two reasons.

First, parallel modules are not installed with individual bypasses. Secondly, we are only interested in how reliable the module itself is. Further inspection of the data sheet shows the real MTBF, to be 30,000 hours without bypass. The MTBF of a system comprised of x modules, each having MTBF equal to MTBF mod, can be expressed as follows:

$$MTBF_{system} = \frac{MTBF_{module}}{X}$$

The MTBF of this proposed system is:

$$MTBF_{system} = \frac{30{,}000}{7} = 4{,}300 \ hours$$

If we want to get an idea of just how likely this system is to fail in any given period of time (say, one month), we can look back at our formula:

$$Pf = \frac{t}{MTBF}$$

with:

$t = 1\ month\ (730\ hours)$

$MTBF = MTBF_{system} = 4{,}300$

Thus:

$$Pf = \frac{730}{4{,}300} = 0.17$$

In other words, there is approximately one chance in six that a module will break in any given month. These are not very good odds, but believable to many who have owned a big static UPS system.

Rotary Ups System

Rotary technology lends itself to the use of larger modules with ratings up to 1,400 kVA. Using larger modules means fewer parts. A typical PS&C *Series XC* module has one-fourth fewer parts than a static UPS module. Fewer parts equals greater reliability.

Using bigger, more reliable modules offers better results. The 3,000 kVA system will require only three modules, plus one for redundancy. Thus, a rotary system's MTBF would be:

$$MTBF_{system} = \frac{150{,}000}{4} = 37{,}000\ hours$$

Thus:

$$Pf = \frac{t}{MTBF} = \frac{730_{one\ month}}{37{,}500} = 0.02$$

This is one chance in fifty. Odds of one in fifty are far more comfortable than one in six, by a factor of better than 8 to 1.

To get the most meaningful comparison between two possible UPS systems, it is necessary to do the following:

1. Find out what the *REAL* reliability of a module is. Ignore assumed transfers to bypass.

2. Decide what really constitutes a failure. Recognize that any failure of a component or module within the system is a failure overall, since a service person must be called.

3. Evaluate the probability of a failure occurring over some relatively short period of time, like a month. Compare these results for the alternative systems to determine relative reliability.

4. As the calculations show, what this really means to the Facilities Manager is that a static UPS module has the probability of failure once every six months.

5. Frequent failures equate to more risk for the critical load.

When examined closely, the results are inescapable - the use of PS&C Rotary Hybrid™ UPS offers the best possible system reliability. And what does reliability really mean? More uptime and fewer calls at three o'clock in the morning.