UPS APPLICATION PAPER

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Diesel Start Reliability & Availability

An unbiased compilation of diesel generator failure-to-start data can be found in the IEEE Gold Book" Standard 493 on Design of Reliable Industrial and Commercial Power Systems. Appendix L (attached) documents a starting reliability of 0.99492 (average) for standby diesels. A second credible database, the 12/98 IEEE-IAS RAMP study, puts standby packaged genset start reliability even higher at 99.94%. A 99.5% start reliability figure may not seem particularly impressive for mission-critical systems, but it is. One needs to bear in mind that the "99.5" is "starting reliability" value, not an availability value (which may confuse many), and so needs to be converted to that. Here's how.

Most USA critical power sites experience 200 hours/year or less in standby genset run time. Therefore the vast majority of component failures common in continuous duty gensets (pistons, heads, etc) are not seen in standby service. Standby diesel gensets in critical load applications, by definition, do not necessarily start every day or even every week. How often they are called upon to start depends largely upon two factors. First is the type & frequency of power disturbance, and the second is the type of power storage device between the utility and the critical load. In the case of a UPS with Flywheel rather than battery, there is a minimum of 12 - 15 seconds available in continuous critical load power reserve. This is more than enough time to allow for diesel start & load acceptance (6 to 7 seconds worst case). This also gives several seconds left to "watch" utility before triggering diesel start should the situation require it.

Next we determine just how often disturbance events occur which last beyond the 1 – 3 second "watch" (no genset start) window. An excellent source for this is EPRI. The EPRI DPQ study (attached) examines some 24 utilities across the USA over two years. The results document that an average of just two (2) of all of the disturbances measured annually exceed the coverage window offered by the flywheel-backed UPS without diesel backup. Therefore, for Flywheel-protected sites, diesels need to start, on average, less than twice a year to provide complete protection. At the IEEE 99.5% diesel start reliability, true availability/reliability is tied to the equivalent of 2 x (100% - 99.5% = 0.5%) = 0.01 failure events per year or just 1 fail-to-start every 100 years! In running time, that would equate to an MTBF of almost 2,000,000 hours. Even this value is conservative since the IEEE gold book figures do not differentiate between high-availability data center back-up gensets and conventional gensets when looking at start failures. The "99.5%" genset start reliability figure may and likely would actually approach 99.9% where fuel analysis, redundant starting, and 7x24 test & maintenance procedures are required.

Flywheel UPS availability figures therefore match the 99.999 to 99.9999 availability values of battery-based UPS systems (or may greatly exceed in the case of VRLA), depending upon redundancy considerations of either system.

Maintenance is key

Mission Critical West is often asked to recommend redundancy configurations for various clients. When it comes to stand by diesel gensets, if I had the choice between one well-designed, tested and well-maintained genset, or two (N+1) redundant gensets with mediocre maintenance, I would take the former every time. The August 2003 blackout, the largest ever in our history, bears testimony to this. While there were countless stories of UPS batteries that failed when they were needed most, there were also cases of gensets which failed to start, or started, then stopped unexpectedly. In the vast majority of cases, the causes for the failures were either bad design and/or poor maintenance.

Batteries, again the culprit

The single biggest cause of failure to start in diesel generators is bad batteries. Over 90% of diesel generators are equipped with inexpensive batteries to keep bid prices low. Rather than relying on non-redundant lead acid batteries (such as in your car), mission critical starting systems require more. But even if redundant batteries are employed they may be allowed to age excessively, particularly under high ambient temperatures, resulting in high risk of failure. Good maintenance means monitoring battery age, temperature and charge/discharge levels. If you allow your site to crash because of a couple of hundred dollars worth of batteries not replaced, you have only yourself to blame. Other alternatives to improve starting reliability include air start, NiCad batteries, and rectifier systems.

Other issues

Fuel problems also emerged as a cause of gensets stopping during the 03 blackout. In some cases, fuel valves were turned off or tank transfer pumps were found to be on utility rather than genset power. In other cases, fuel was contaminated with water or sludge due to improper maintenance or testing. Another common but easy to address problem was having ATS switches locked out or in the wrong position.

Summary

No 7x24 data center or critical operation would consider ignoring maintenance on its UPS system. The same needs to be the case with a site's stand-by diesel genset. With good design, testing and regular maintenance, genset starting well within a 10 second window is assured.