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MTBF AND MTTF OF APOLLO SOLAR'S TELECOM ENERGY SYSTEMS

Apollo Solar believes that the Reliability Demonstration Methods of determining figures for MTBF and MTTF are more meaningful and accurate than the Reliability Prediction Methods. One can read many technical articles discussing this subject.

Virtually all the Apollo Solar PVT systems are connected to our server using our Remote Monitoring software. The data used to form the conclusions below was harvested from the database on our server. Therefore we can be certain that the systems were actually installed and continue to operate fully today. Any failure of a T80HV, or other major component, is reported instantly and automatically.

MTBF is used for products or systems which can be repaired, so the Mean Time Between Failures applies to the Apollo Solar PV for Telecom Systems.

MTTF (Mean Time To Failure) applies to Non-Repairable products. This relates to the T80HV which is a component in our PVT systems which is replaced in the field rather than repaired.

It is important to understand that essentially all of the Apollo Solar PVT systems use more than 1 and sometimes 4 to 6 T80HVs in parallel so a failure of any single T80HV will not cause the PVT system to fail to charge the battery. The chances of all the T80HVs failing at the same time is extremely small. Furthermore, the PVT system is a battery based system. This means that the power to the load, which is the important point in this discussion of reliability will continue to provide that power to the load for up to 3 to 5 days even if all the T80HVs were to fail to provide charge to the battery. It should also be mentioned that all of these systems were Pure Solar with no generators for back-up, so the reliability of our systems receives constant attention from our customers.

In addition to the inherent reliability provided by using multiple redundant devices for the Charge Controllers, all the other parts in the power path which represent a possible single point of failure are passive by nature. In other words, by design, the only parts in our PVT systems which do not have redundancy are the wires, connectors, circuit breakers and relays.

Determining the honest MTBF of the PVT system has been a challenge because in the 5 years since we have been delivering these systems there have been zero system failures. That is, no BTS telecom tower system powered by the Apollo Solar PVT system has ever lost power to the BTS. The system UP-TIME is 100%. There are now over 1000 of these systems installed and running continuously and many of them are in challenging climates. If we left the discussion at this point, one might conclude that the MTBF was some impossibly large number on the system level.

The T80HV Charge Controller is the most complex device inside the PVT systems. It has the most discrete components and is subjected to the highest heat during the daytime and therefore has the highest rate of failure. The T80HV is powered from the system battery so it is powered on

continuously 24 hours a day, 365 days per year even though the power it handles is very low during the dark hours.

Since there is an average of about 2.5 of the T80HVs in each PVT system, the total number of T80HVs working in the field is about 2500 today. The average number over the 5 years using the straight line method is 1250. There have been about 50 failures of T80HVs reported during the 5 years. They were replaced when it was convenient for the local maintenance contractor. It is one of the benefits of the Apollo PVT product that expensive panic based emergency service calls are virtually eliminated so it is not appropriate to use a long delay in replacement as a negative impact in the reliability discussion in terms of a high **MTTR** (Mean Time To Repair).

In any case, we can assume that a T80HV that failed would most likely be replaced within 2 weeks. This will take 336 hours out of the total run time. With 50 such failed units, the total lost run time would be 16,800 hours.

To distinguish between MTBF and MTTF, the concept of suspensions must first be understood. In reliability calculations, a suspension occurs when a destructive test or observation has been completed without observing a failure. MTBF calculations do not consider suspensions whereas MTTF does. MTTF is the number of total hours of service of all devices divided by the number of devices.

MTTF is equal to the Total Time that all devices were running divided by the number of units in the test sample. The number of units is 1250.

$$\text{MTTF} = \frac{\text{Total Run Time for all devices}}{\text{Units in the test sample}}$$

5 years = 43,800 hours

50 failed units subtracts 16,800 hours from the total run time

Total run time is therefore 27,000

Multiplied by the 1250 units is 33,750,000

$$\text{MTTF} = \frac{33,750,000}{1250 \text{ units}} = \mathbf{27,000 \text{ hours} = 1,125 \text{ days or 3.08 years}}$$

The MTTR (Mean Time to Repair) is not applicable in this discussion since the PVT system is still working and the T80HV is not repaired, but replaced. The time to execute the replacement is not a function of the Apollo Solar equipment, but rather the logistics of the maintenance contractor.

John E. Pfeifer, CEO
Apollo Solar, Inc.