The Need to Segment Abnormal Events from the Calculation of Reliability Indices

James D. BOUFORD, *Senior Member, IEEE*

***Abstract*—The abnormal events that seriously impact an electric utility's operational ability to provide reasonable customer service must be removed from the calculation of reliability indices, and be reviewed individually. This will allow an accurate indication of both the system's reliability trend and the ability of the system to respond to abnormal events. Different processes, management talent, workforce efforts, and leadership are required to respond to these two types of reliability impacts. Different reviews are also required.**

***Index Terms*—Abnormal Events, Classification of Events, Major Storms, Reliability**

THE use of customer reliability indices is almost universally accepted by utility management and regulators as a measure of customer service level. Increasingly, they are being proposed as a measure of the adequacy of a utility's system infrastructure addition and maintenance efforts. In addition, the comparison of utility reliability performance is being utilized in benchmarking studies. With this level of scrutiny being applied, it is imperative that the measures of reliability are a true representation of the system's performance.

The electric utility delivery industry has developed standard reliability indices to be used for the above purposes. These can be found in IEEE *Full Use Guide for Electric Power Distribution Reliability Indices* 1366-2001, and the specific indices will not be discussed in any detail herein. The indices are accepted because they are easy to calculate, the data required can reasonably be obtained, and they provide a fair insight into the system performance.

No electric delivery system can economically be constructed and/or operated to provide power 100% of the time under all possible conditions to all customers. It is generally understood by those who operate, maintain, manage and regulate electric utilities that the delivery systems are planned, designed, constructed, maintained and operated to adequately and reliably handle a certain level of disturbances. The measure of a system's reliability should reflect the ability of the system to address that level of disturbances for which it was planned, designed, and constructed, and is maintained and operated.

These measures, used to determine if an electric delivery system is performing to an accepted level, should produce consistent results for unvarying levels of effort by the system owners in planning, designing, constructing, and running the system. In an ideal world, the reliability measures would be the same from year to year, if the system owners did nothing to change how the system was planned, designed, constructed and operated. A trend of the measurements should then be used to evaluate any change in the customer service level and the ability of the company to maintain an adequate level of reliability.

An electric delivery system that is well planned, well designed, well constructed and well run (operated and maintained) will still have service interruptions. Maintained equipment will still fail, drunken drivers will still run into poles, lightning will still strike the lines. Companies have significant control over the internal factors that cause reliability problems; maintenance schedules, switching orders, etc., but only limited control over external factors; severity of storms, squirrel populations, sobriety of drivers, within the design constraints built into the existing system. Controlling the internal factors has a positive impact on reliability performance. External factors, however, can only affect the reliability of an electric delivery system in an adverse way, since nothing that happens from outside the running of the system improves the reliability.

The majority of interruption events are of a recurring nature and affect the reliability measures, over periods of time, in a rather consistent manner. The system can be planned, designed, constructed and run in an economical manner that anticipates their occurrence. However, external factors are not evenly distributed as to their severity.

Some external events are of such magnitude in their effect on the reliability of the utility that the reliability measures are distorted. These *abnormal events* occur infrequently. Usually, the system owners must implement extraordinary procedures to address the impact of these events; reassignment of personnel between operating areas, request mutual aid, and request emergency delivery of materials from suppliers, for example. These events should not be utilized in the measurement of the system's reliability performance.

Manuscript received March 15, 2002.

James D. Bouford is the Manager of Distribution Performance at National Grid, Northborough, MA 01532 USA (telephone: 508.421.7648, e-mail: james.bouford@us.ngrid.com).

An abnormal event must exceed the reasonable design and operational limits of the electric delivery system. The effect of design limits being exceeded is severe damage or destruction of the electric delivery infrastructure. An ice storm, hurricane, widespread and severe lightning storm, tornado, avalanche, forest fire, or a myriad of other such events would exceed reasonable design limits. This list is not meant to be complete. No system, even those built to the National Electrical Safety Code (NESC) requirements, could be expected to withstand the onslaught of such events.

The effect of operational limits being exceeded is the inability to adequately respond to the interruptions with the available manpower, equipment, materials, or automated systems. The events noted in the prior paragraph would also tend to exceed reasonable operational limits. An abnormal event requires a lengthy restoration period. Workers must be reassigned and/or brought into the system from outside. Automated restoration systems must be unable to effect the restoration by themselves. Damage must occur to the infrastructure. This may involve a rather small number of customers, such as when a tornado sweeps through an area, but will always involve a large number of customer hours. If an event does not involve a large number of customer hours, it has not exceeded the reasonable operational limits.

Some types of events could exceed design limits, with the result of limited damage or destruction to the infrastructure, which would not require emergency operational efforts to repair. These events should not be designated abnormal events on the sole basis that they exceeded the design limits.

Chart 1 shows the result of abnormal events on the SAIDI per day values for a large utility. This chart only plots the values for the highest 60 days of the three years of data available in order to present the details. The large exponential increase in SAIDI for the few highest days is an indication that the operational forces available at this utility were being overcome by the severity of the events on those days. It can also be seen that at lower levels of SAIDI per day step increases occur that appear to show initial levels of breakdown of the ability of the utility to handle the events that occurred on those days.

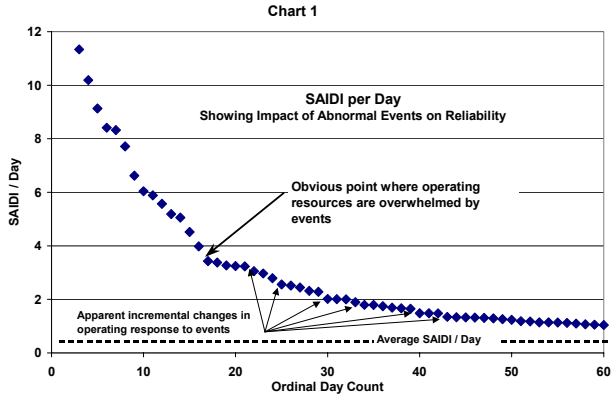

Figure 1. SAIDI per Day Values

Chart 2 is a presentation of the past seven years of actual SAIDI data for a utility system. The solid line is the yearly SAIDI values and the dashed line is the average SAIDI over the seven-year time frame. In this chart, no events were excluded from the calculation of SAIDI. It would appear that this system had 3 years of improving performance, from 1996 to 1998, followed by two reasonably average years, one slightly worse than the average and one slightly better than average, and then, one terrible year. The initial impression of most folks viewing this data would be that the reliability of this system is *degrading quickly*.

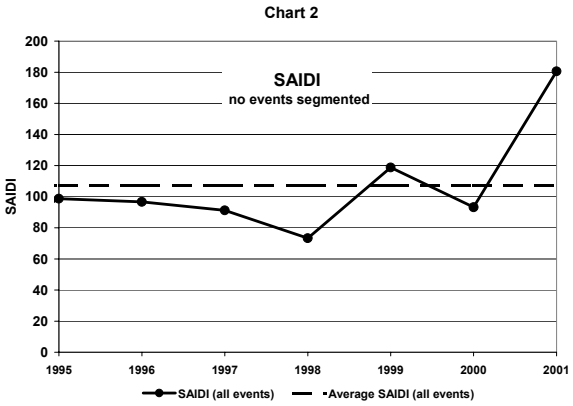

Figure 2. System SAIDI for Seven Years

However, two things need to be noted. First, a new system of capturing the interruption data was installed in 1998 that appears to now find the 20%, or so, of the events that had previously been lost in the prior, mostly manual, system of data collection. Second, 2001 brought a new type of thunderstorm to the region where this utility is located. Instead of the storms quickly blowing through the region, hitting an area with wind, lightning and sometimes hail for an hour or so and then moving on, storms would just sit in an area and pummel it for a whole day. Wind, rain and lightning would be continuous for 8 to12 hours.

So, now the points I wanted to make:

1) The *design limits* of the system were not exceeded. The system has been designed and built to the NESC. The *operational limits* were exceeded. This system, as every other utility system, was not, and will not be staffed to meet the requirements of the aberrational storms that occur. Even though the number of events for the day of a storm may not be above average, the impact of them occurring within a very short period of time will exceed the utility's ability to respond in a normal manner.

2) Not removing the effects of those events that exceed the design or operational limits of a system will distort the efforts, or lack thereof, of a system to respond to reliability issues.

Chart 3 shows the effect of removing abnormal events.

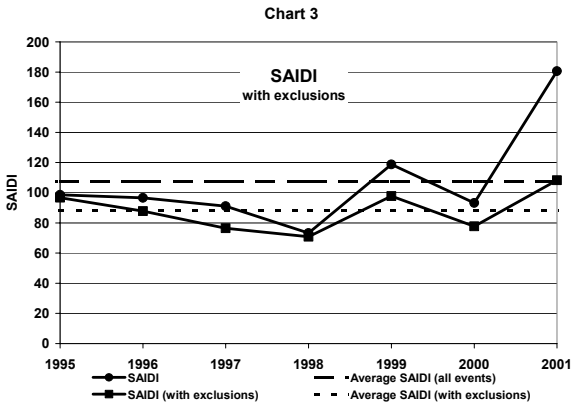

Figure 3. System SAIDI for Seven Years With Abnormal Events Removed

It should now be obvious, from the new values, that the system reliability was improving for the first 3 years, but, it really wasn't significantly better than average. This is a different interpretation than before. The next two years again are average, as before. The last year still shows that it was not a good reliability year, and that is indeed correct, a larger than normal number of non-storm related incidents did occur.

Hopefully, it is obvious from the above that if one wishes to truly measure whether a system is being planned, designed, maintained, and operated to meet the reliability requirements of the customers, abnormal events that exceed the established design and/or operation criteria of the system must be excluded from the measurement. The Company's response to those abnormal events that are removed from the reliability calculations must be reviewed in a manner different than that used for everyday interruptions, since the response to abnormal events requires a different set of talents, processes, and leadership.

Those events that would distort the reliability measures, and present an unrealistic interpretation of the system operator's efforts to maintain a consistent level of reliability, must be reviewed differently. It is the response to these events, the frequency of their occurrence, and their cause that is important to the customer, and therefore to the regulator. Each event that is not used to determine the *normal* level of reliability for a system must be reviewed, in depth, to ensure that the impact of these events is not magnified by a deteriorating system.

Rather than just eliminating the abnormal events described above from the reliability review, two reviews are required; 1) a measurement of the efforts expended to maintain, and improve, or the lack of efforts leading to a degradation of, a system's inherent level of reliability, (the reliability indices, minus abnormal events, provide an adequate indication) and, 2) a measurement of the ability of the system to respond adequately to the devastating effects of abnormal events, (an in-depth analysis of the response to each individual abnormal event is required).

A separation of the two very different interruption conditions allows regulators to actually better review the operational ability of the companies to respond to the reliability portion of service quality issues. This is done by separating out the impact on reliability indices, resulting from the company's daily, or *normal* operational readiness, from the impact that the company's storm, or emergency preparedness has on the impact of *abnormal* events; storms, earthquakes, floods, terrorist attacks, etc. If a company tried to game the process, the detailed review of the abnormal events; questioning the adequacy of the staffing, the inventory levels, the use of mutual aid from other utilities, the shifting of resources between operating areas, etc., would ferret out this behavior.

An electric delivery system that is allowed to deteriorate will tend to have an increasing number of abnormal events over time. This system will also have an increasing number of normal events over time. The measure of the system reliability will show that the system is deteriorating. The increasing number of abnormal events *may* indicate that the system is deteriorating, the number of significant external factors may indeed be increasing, even for a system that is improving its normal reliability.

I. Conclusion

The calculation of reliability indices, without removing the abnormal events that distort the year-to-year results, will not accurately represent the efforts of the utility to provide the required customer service. It is the trend of the system reliability, and, the response to individual major events that is important.

II. References

Technical Reports:

[1] Richard D Christie, Charles W Williams, Cheryl A Warren, "*Descriptions of Candidate Major Event Day Classification Methods*," February 8. 2002.

Papers Presented at Conferences (Unpublished):

[2] Richard D. Christie, "Statistical Methods of Classifying Major Event Days in Distribution Systems," prepared for the Summer Power Meeting 2002,Chicago, IL, USA.

[3] Daniel A. Kowalewski, "A Comparable Method for Benchmarking the Reliability Performance of Electric Utilities," prepared for the Summer Power Meeting 2002,Chicago, IL, USA.

[4] David J. Schepers, "Reliability Surveying - Segmenting For Comparability," prepared for the Summer Power Meeting 2002,Chicago, IL, USA.

[5] Cheryl A. Warren, "Overview of 1366-2001 the Full Use Guide on Electric Power Distribution Reliability Indices," prepared for the Summer Power Meeting 2002,Chicago, IL, USA.

[6] Charles W. Williams, "Major Reliability Events – Self-Defining?," prepared for the Summer Power Meeting 2002,Chicago, IL, USA.

Papers from Conference Proceedings (Published):

[7] Richard D. Christie, "Statistical Classification of Major Reliability Event Days in Distribution Systems," submitted to *IEEE Power Engineering Society Transmission and Distribution*

Standards:

[8] *IEEE Full Use Guide for Electric Distribution Reliability Indices*, IEEE Standard 1366-2001, March 2001.