A Chloride Power Protection Company

White Paper

The Case for Prescription Power:

Medical System Field Trials

This paper describes the technical relationship between power and medical system reliability and discusses the business benefits of effective power conditioning.

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Introduction

It's a fact of life — modern electronic medical systems can perform more tasks and achieve better and faster results. They're also more sensitive to certain types of failures. These failures are related to the quality of the electrical environment in which the equipment operates. We can't blame the utility company because the electrical environment has not changed. The changes have occurred in modern electronics and, to an extent, in hospitals and labs. Breakthroughs in technology have increased the susceptibility of equipment to disturbances that have always been a part of the electrical environment. And as sophisticated electronic equipment becomes more and more critical to the health care delivery system, the "Case for Prescription Power" becomes even more compelling.

The Electrical Environment

All electrical environments are hazardous places for electronic equipment. The only issue is how hazardous. Everyone understands the need to protect from lightning, but few are aware of the "lightning storms" that are continuously created within buildings by the normal functioning of their electrical equipment.

These internally-generated disturbances are constantly present and insidious. They are most often the culprits that lower system reliability and cause soft failures such as inconsistent test results, compromised system performance and intermittent errors. They also cause most of the hardware failures. Known by a series of names such as "transients," "spikes," or "electrical noise," this high frequency energy is created whenever certain types of electrical equipment are in use. Photocopiers, elevators, dimmer switches, heating, ventilating and air conditioning systems are just a few of the noisy electrical loads in most buildings. They all inject harmful electrical disturbances into the power system that will ultimately reach your equipment.

Before integrated circuits came into use, electronic equipment was rugged enough to withstand the detrimental effects of electrical noise. In other words, the AC Power was "pure" enough. Not so today. With changes in technology, particularly in the areas of power supply design and chip miniaturization, electrical noise tolerances are far lower. Therefore, what used to be sufficient electrical protection is no longer appropriate.

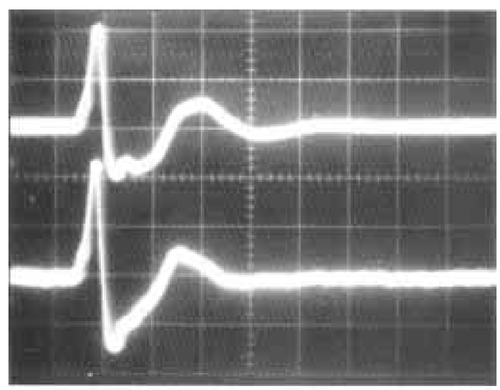

Fig 1: Actual noise measurement taken from an AC outlet next to an office photocopier in operation. The top trace shows 60 volts peak-to-peak of normal-mode noise (between hot and neutral). The lower trace shows 18 volts peak-to-peak of common-mode noise (between neutral and ground).

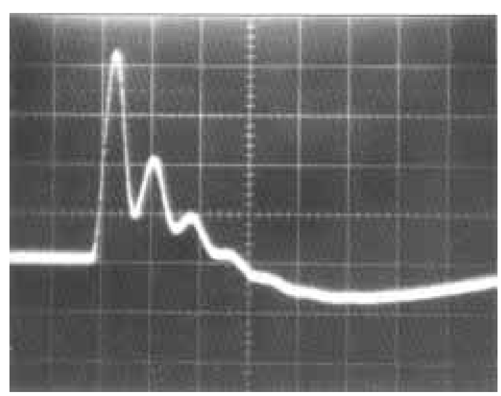

Fig 2: Noise measurement made adjacent to a lighting dimmer switch. Over 200 volts peak-to-peak of normal-mode noise is present.

What’s Enough Protection?

Studies show that as much as 80% of all hardware failures in modern electronic equipment are the result of electrical noise — power that wasn't pure enough. Therefore it stands to reason that if the electricity reaching such systems didn't also have these harmful properties, than a large number of failures would be eliminated.

An easy way to visualize this is by looking at the familiar bathtub curve. Figure 3 shows the expected failure mechanism of semiconductors, from burn-in, through the infant mortality period in the field, to the point of wear-out. By controlling the electrical environment, the entire failure curve can be brought down (Figure 4). The space between the curves represents the improved reliability that is the result of effective power conditioning.

It is extremely difficult to define the operational sensitivity of components within a system. Because of this, it is almost impossible to say with assurance that anything other than the most stringent controls is enough. It stands to reason, therefore, that more protection is certainly preferable if cost-effective. Protection specifications emerged in relationship to standards developed by IEEE and ANSI with the goal of controlling the electrical environment within buildings so that the noise levels are totally safe for electronic equipment.

In these standards, electrical disturbances are described in two forms, normal-mode and common-mode. Normal-mode noise exists between line and neutral, and common-mode is noise between line or neutral and ground. Common-mode specifications must be more stringent because of the direct path the ground wire has into the system logic.

If noise levels are kept to 10 volts normal-mode and 1/2 volt common-mode, then electronic systems will have protection that is compatible with their sensitivity. This level of protection will insure that your equipment will follow the lowered failure curve defined in Figure 4 of the bathtub curve. It is this lowered failure rate that can be translated into a decrease in inconsistent test results, compromised system availability and delayed patient care and processing.

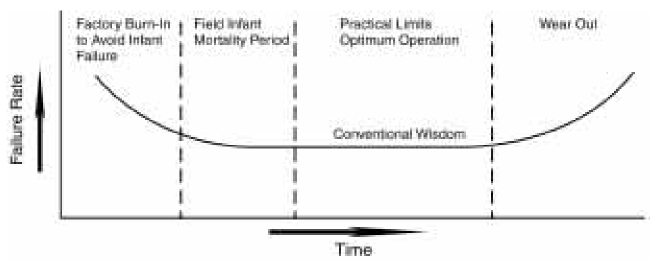

Fig 3: Conventional Wisdom

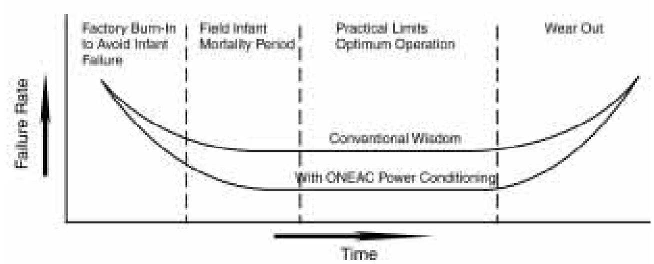

Fig 4: Conventional Wisdom with ONEAC Power Conditioning

Medical System Reliability

The medical field employs a wide range of equipment which bears little apparent commonality of purpose or design. However, from an electrical perspective, similarities are significant. Virtually all modern electronics are more susceptible to malfunctions caused by power line noise because of the equipment's increasing dependence on electronic circuitry. To complicate the problem, patient contact equipment has stringent safety standards that require different electrical design approaches.

Simplistically, from an electrical perspective, all electronic systems can be described in the medical system block diagram in figure 5 below. They contain an AC to DC power supply that feeds the digital logic. Feeding that entire system is the AC power that enters the system along the three wires — hot, neutral and ground. Because the ground wire travels directly to the digital logic, it is critical to control the amount of electrical noise that exists on this ground.

Because of the nonlinear operation of the switch-mode power supplies used to convert AC to DC, a low impedance path for AC power to the supplies must be preserved. This permits current to be drawn in the brief pulses characteristic of switch-mode power supply design and allows the supply to operate within the limits of its design.

Medical systems are often configured using separate peripherals, such as printers and computers. To ensure reliable system operation and to minimize disruptions, the concept of single point grounding must be incorporated whereby all AC grounds should be brought back to one common point to eliminate differences in ground potentials.

Optimal power protection for medical electronics should accomplish the following:

- Reduce electrical noise from all sources to levels that are below the disruption thresholds of the equipment (10 volts between line and neutral, and 1/2 volt between line or neutral and ground).
- Provide a low impedance source of AC power to the AC/DC supply.
- Implement single point grounding for the system and all its peripherals.
- Preserve patient safety in the electrical environment.

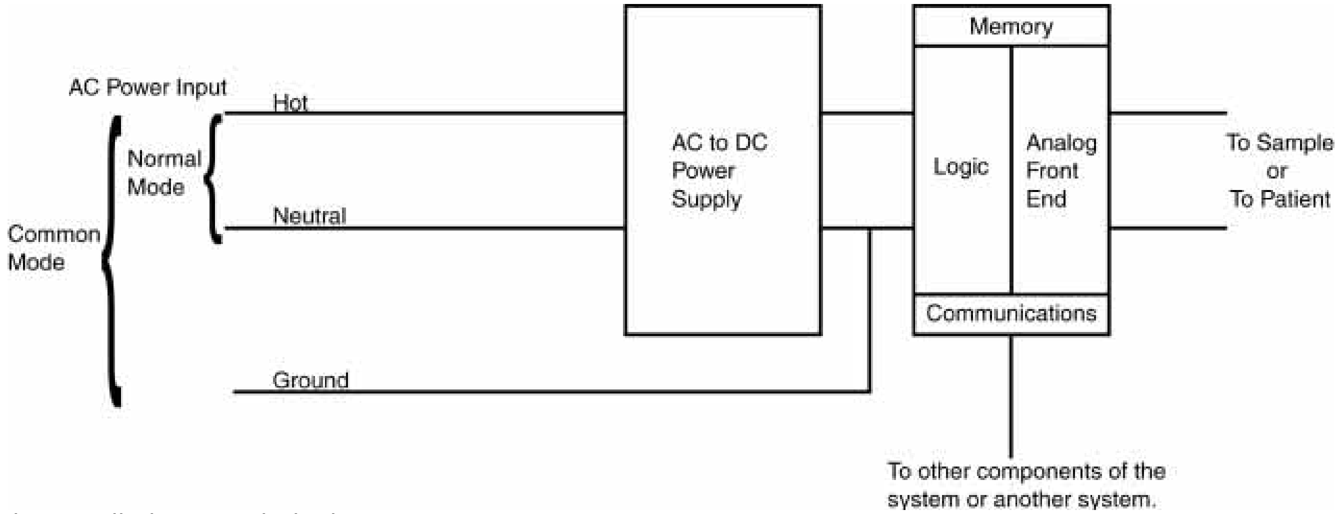

Fig 5: Medical System Block Diagram

Medical System Trials

Obviously, more protection is better than less. But how do you justify its cost? One approach to proving the value of power conditioning is to quantify the improvements in system reliability in the field. Over the past several years, ONEAC has sponsored numerous trials in conjunction with medical equipment manufacturers. These trials were with a variety of medical equipment. All of the trials were done under test conditions supervised by the manufacturer, and generally took the form of a "before" and "after" study. Service information on the systems was generally compiled for a period of three months prior to conditioning. Then ONEAC power conditioners were installed, and three more months of data were collected. The primary criteria to be measured were increased Mean-Time-Between-Service-Calls (MTBSC) and decreased cost of servicing the equipment. A number of the trials are outlined here.

The graph in figure 6 represents the results of a field evaluation of 16 laboratory systems that were considered to be installed in "problem site" locations. The data indicates that for identical periods — before and after the installation of power conditioning, the average number of service calls was reduced from over 6.5 to 4.1. The MTBSC was improved by 65% from 1.9 weeks to 3.2 weeks.

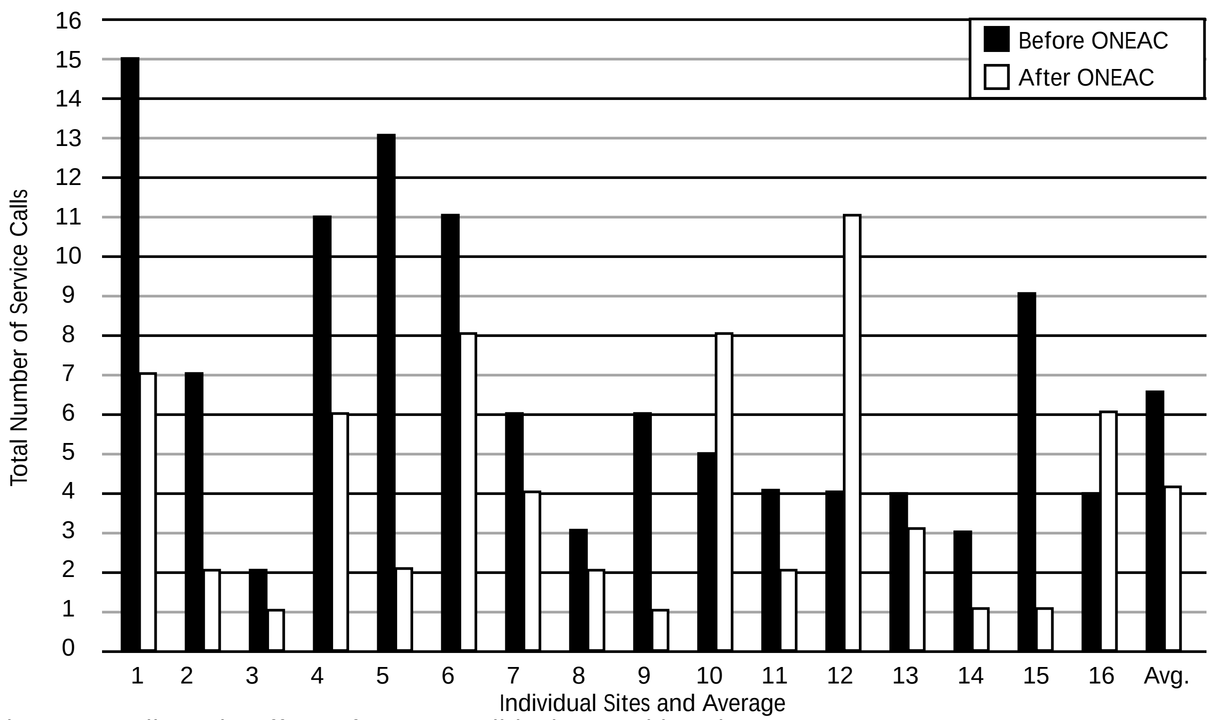

Fig 6: Lab System Trail #1: The effects of power conditioning "problem sites"

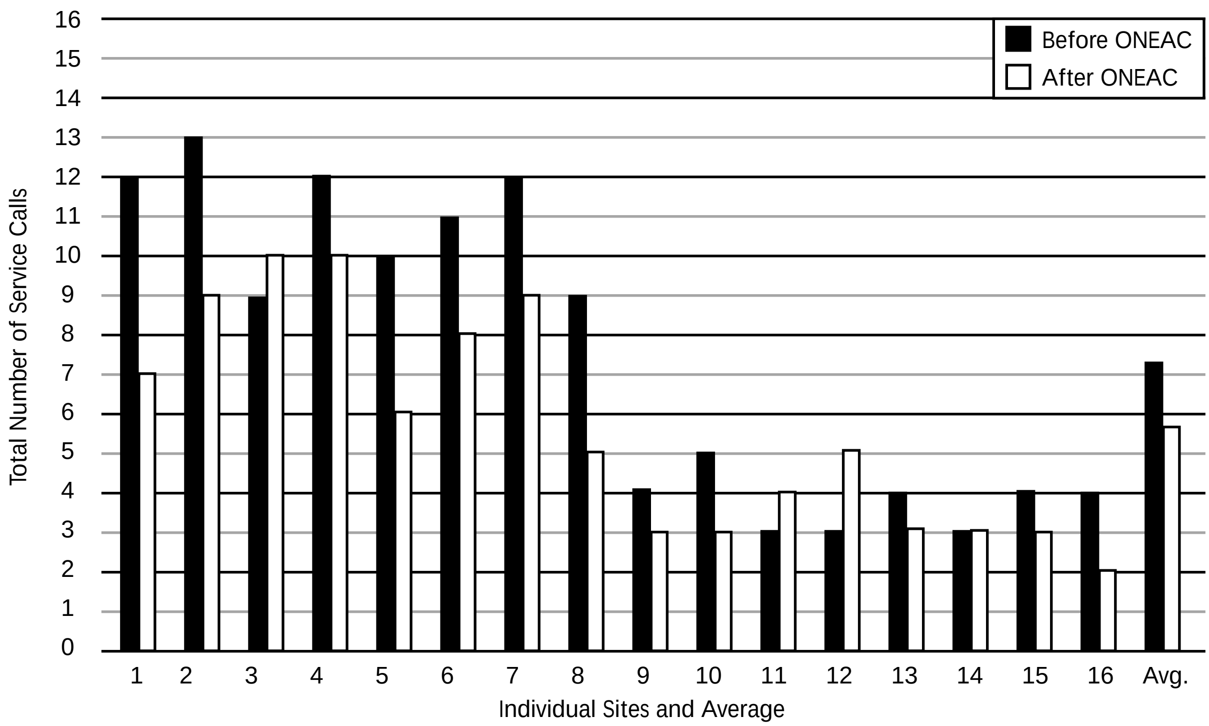

Fig 7: Lab System Trial #2: The effects of power conditioning both "problem site" and "average sites"

The data in figure 7 graph represents the results of a similar field evaluation for 16 sites — eight of which were considered to be average sites, eight of which were considered to be problem sites. The average number of service calls for all the sites was reduced to 5.7 from over 7.2. Again, the MTBSC was increased 31% over the entire test spectrum.

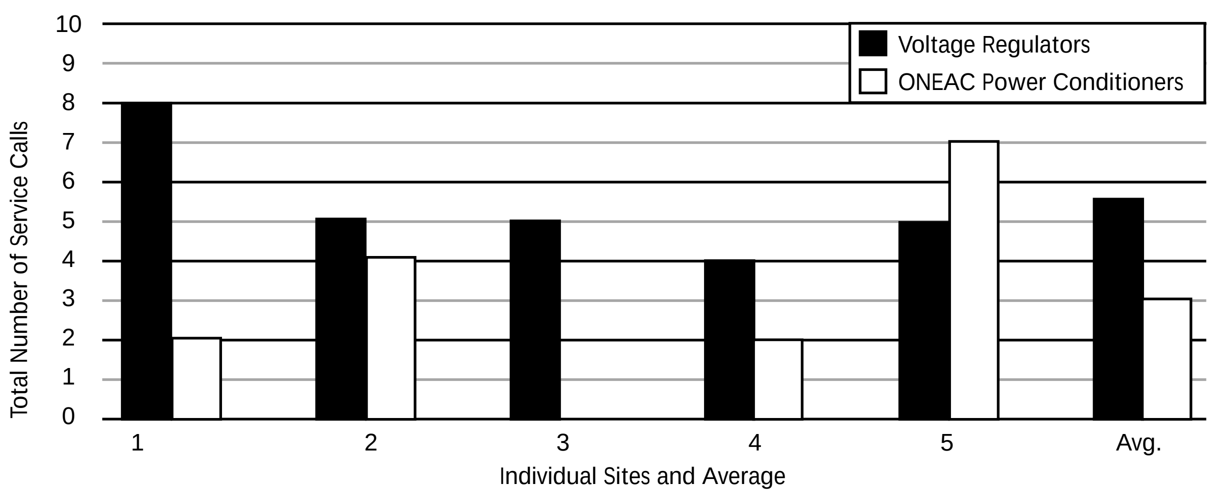

Fig 8: Lab System Trial #3: Power Conditioners vs. Voltage Regulators

The graph in figure 8 represents the results of trial #3 comparing the performance of ONEAC power conditioners versus voltage regulators. Using voltage regulators, the average number of service calls was 5.5; using ONEAC power conditioners, the average was reduced to 3. The average MTBSC increased from 5.5 days to 13.4 days — a 145% improvement.

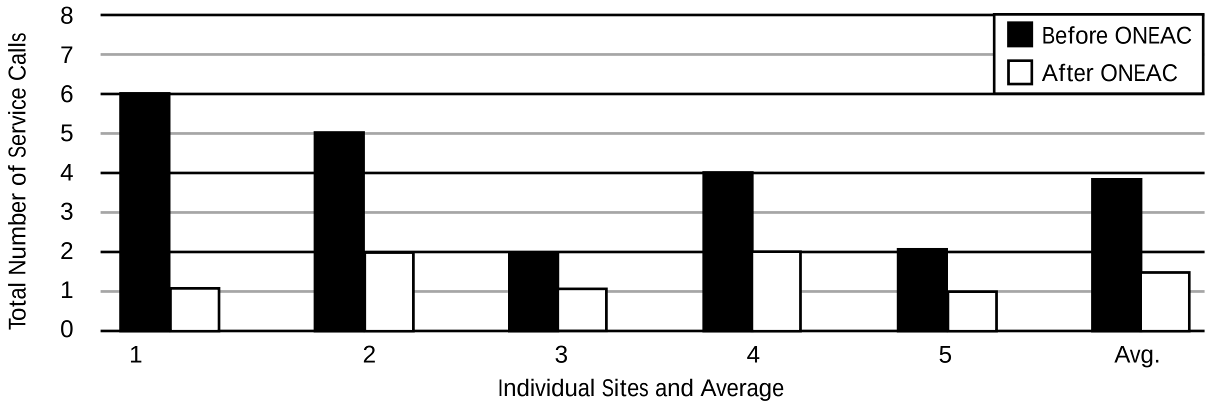

Fig 9: Patient Monitoring Trial #4: The effects of power conditioning on “no trouble found” service calls

The graph in figure 9 demonstrates the reliability improvements achieved on sites that were experiencing a large number of “no trouble found” service calls. Prior to conditioning the power, the average MTBSC was 7.4 days; after conditioning, it was 20 days; representing a 170% improvement. The cost of servicing the equipment was reduced by 77%.

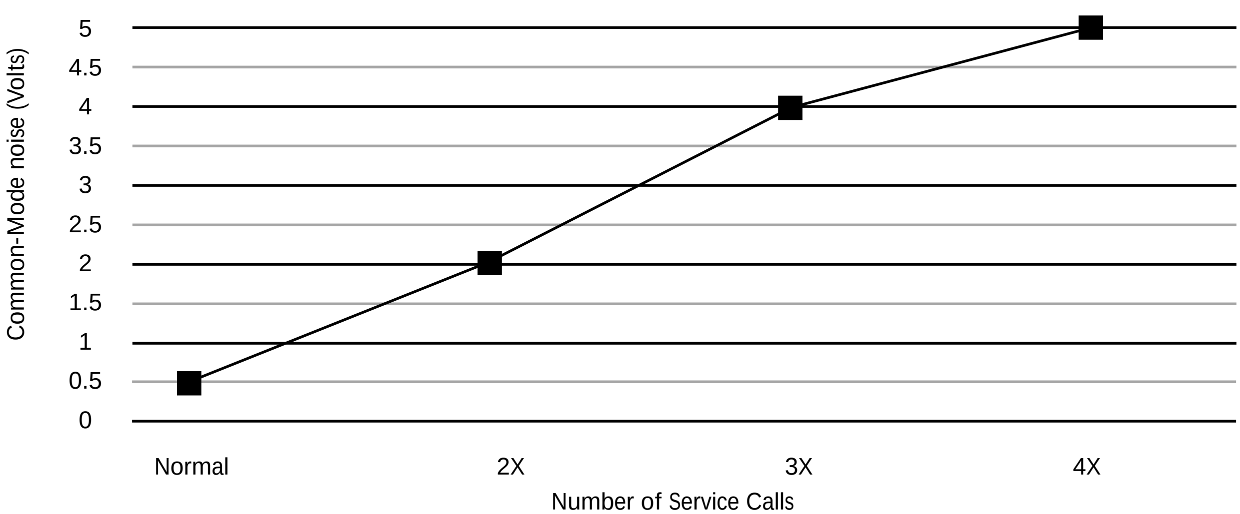

Fig 10: Imaging System Trial #5: The relationship between common-mode noise and service calls

The graph in figure 10 represents the relationship between common-mode noise (noise between hot or neutral and ground) and service call rates for ultrasonic imaging systems. The data was collected from measurements taken at approximately 200 sites at the time of installation. The data shows a marked correlation between the factors of ground noise and service calls.

Business Benefits

What do all these field trials mean? These results indicate that the vast majority of medical systems can experience significant improvements in reliability if the AC power is properly conditioned. To the extent that an organization depends on its systems to effectively compete, these reliability improvements can have measurable impact. Not conditioning the power can have a negative affect — inconsistent test results, compromised system availability, delayed patient care and processing among other problems can mean lost business, not to mention customer frustration and irritation. Also, a decrease in service calls mean that less time will be spent tracing and solving problems. This certainly increases the productivity of both the staff and the system users.

Conclusion

This paper illustrates the relationship between the quality of electric power and reliability of electronic power and reliability of electronic medical systems which use that power. The evidence shows that:

- Power disturbances ranging form thousands of volts all the way down to 10 volts have a significant impact on the performance and life-span of modern electronic medical systems.
- The quality of the electric power ranges widely from site to site and changes over time, usually from bad to worse.
- With and ONEAC power conditioned product, and ANSI/IEEE C62.41 Category A pulse applied either normal-mode (hot to neutral) or common-mode (hot or neutral to ground) at the input, the noise output voltage will be less than 10 V normal mode and less than 0.5 V common mode in all four quadrants.
- ONEAC power conditioning reduces service calls not only at "problem sites" but at "average sites" as well, especially in the area of hardware failure and "no trouble found" calls. This translates into better performance and higher reliability for the whole spectrum of medical electronics.
- ONEAC also offers a line of power conditioners and power conditioned UPSs which are IEC60601 compliant, making them suitable for patient contact environments.

Across-the-board application of ONEAC power conditioning is easily cost-justified in terms of fewer service calls, less downtime, less business loss and less customer frustration.

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