White Paper

Operating Room Productivity & Revenue Improved Through Use of Fault Location System

Operating Rooms (ORs) account for approximately 67% of a hospital's total revenue and 40% of hospital expenses (including wages)[i]. Given these figures, optimizing all functions within the operating room is vital to maximize business success. The goal is to maximize efficiencies (resulting in increased profits) as well as positively reinforce the prestige of the facility. Often, the reputation of a healthcare facility is adversely impacted when operations are unexpectedly postponed or canceled. Social media is a likely channel to express negative experiences and spread the word.

Surgical delays are multifaceted. A 2016 study in Journal of Patient-Centered Research and Reviews analyzed the reasons for first surgical case of the day delays (which has a cascading effect on scheduling) shows that 88% of surgical procedures are late. Physicians, anesthesia, patient, staff and the facility (ranked from most to least prevalent) are the primary contributing factors to the delay. Unfortunately, in this study 60% of the cases of delays have not been documented. These outcomes provide a perspective why hospital organizations continue to significantly invest in the training, organization and functionality of their operating rooms.

Although many improvements are allocated to human and organizational factors, technical improvements can also vastly improve the percentage utilization of the OR. Implementing the latest technological development in power distribution systems can save the facility thousands of dollars while improving facility reputation.

Wet procedure locations defined in NFPA 99-2012 Healthcare Facilities Code require personnel protection of electrical shock hazards by utilizing either Ground Fault Circuit Interrupters (GFCI) or Isolated Power Systems. Furthermore, NFPA 99-2012 defines all operating rooms as wet procedure locations by default.

Personnel protection from electrical shock is typically provided by a Ground Fault Circuit Interrupter (GFCI) on traditional grounded power supply systems which (without warning) interrupts the supply of power once a current of 4-6mA is detected on the ground line. However, GFCIs are not a preferred method of protection in the critical patient care spaces as the sudden loss of power can be catastrophic.

To ensure continuity of power in the event of a first (ground) fault, electrical equipment located in critical patient care spaces is connected to an ungrounded power supply (Isolated Power System).

A typical layout is shown in Figure 1.

In this configuration, the fault must be detected and eliminated before a second ground fault occurs else the resultant line to line fault will cause an interruption of power. For this purpose, an Isolated Power System is equipped with a Line Isolation Monitor (LIM) which will display/sound an alarm in the event of a fault appearing on the devices connected to the equipment and power outlets. LIMs monitor all circuits connected to the system and are unable to determine which specific circuit is causing the alarm. In case of a fault, the simplified procedure is described below.

With a basic isolated power system, the procedure is the following in case of fault:

- Audible and visual alarm is generated by the LIM
- Depending on the criticality of the procedure at the time of the alarm the clinical staff initially acknowledges & silences the alarm

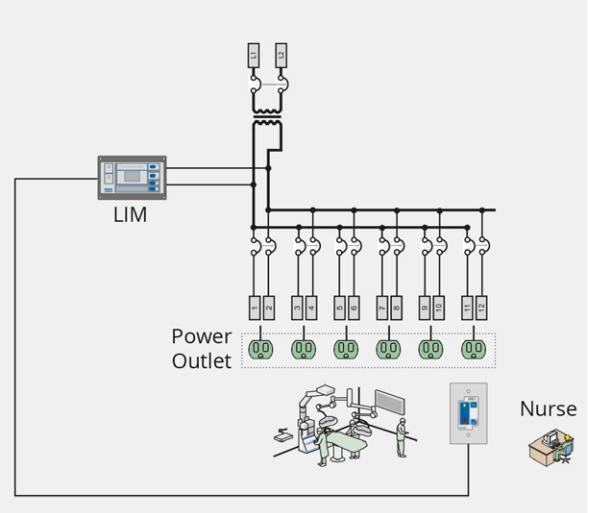

Figure 1: Basic Isolated Power System in OR

- Clinical staff informs biomed or facility maintenance team
- Biomed/Facility maintenance wait until critical aspect of procedure (or complete procedure) is complete before entering room
- Biomed/Facility maintenance searches the origin of the fault (often a tedious process requiring disconnection of equipment and power cycling circuit breakers – sometimes impossible in the case of intermittent faults)
- The Operating Room often remains closed until the root cause and defective device is identified and removed

Risk evaluation of the Basic Isolated Power System

As demonstrated in the above the origin of the fault is unknown. The process of trying to identify the culprit can be tedious and in the case of intermittent faults seemingly impossible resulting in hours or days of surgical delay as well as adverse financial and reputational impact.

The exact financial impact for every OR is difficult to evaluate; however, a 2018 article In Annals of Surgery[iii] estimates a cost of $37/minute for a Californian Hospital. If we consider that the OR is open from 7:30 am to 5 pm, with an occupation rate of 85% (8h/day) the cost can be $17,760/day and $372,000/month (5 days a week).

A 2014 study[ii] shows that 5% of the delay came for facility issues which includes ground fault searching efforts. Based on this data, the financial risk is around $18,000/month for one operating room.

The partnership between BENDER and their clients has allowed them to understand these challenges. Subsequently, BENDER engineers developed a solution capable of identifying which particular circuit (and thus often which device) is contributing to the fault. The addition of the fully automated ground fault location systems (EDS Series) is designed to reduce maintenance cost and increase OR utilization. This module allows, with the help of sensors placed on the power supply, the fault to be detected while the system remains energized and without any user intervention. The information appears on the main screen in the OR/ICU. The culprit can either be immediately removed by properly educated clinical staff or removed once maintenance arrives without creating additional delays. Figure 2 below describes the layout of a basic IPS with the inclusion of a fault location system.

With a fault location system, the procedure is simplified in case of fault detection:

- Audible and visual alarm is generated by the LIM
- EDS identifies & indicated which circuit has the fault
- Properly educated/trained clinicians can immediately identify which devices are connected to the faulty circuit and (depending on criticality of procedure at time of fault) isolate and immediately rectify the situation. Alternatively, the clinical team can take note of equipment connected to the faulty circuit to report to Biomed/Facility maintenance.
- The clinical team alerts Biomed/Facility team
- Biomed/Facility team waits for OR availability
- Biomed/Facility maintenance views EDS which indicates the circuit at fault (stored in memory in the case of intermittent faults)
- Biomed/Facility maintenance can remove/replace the defective device

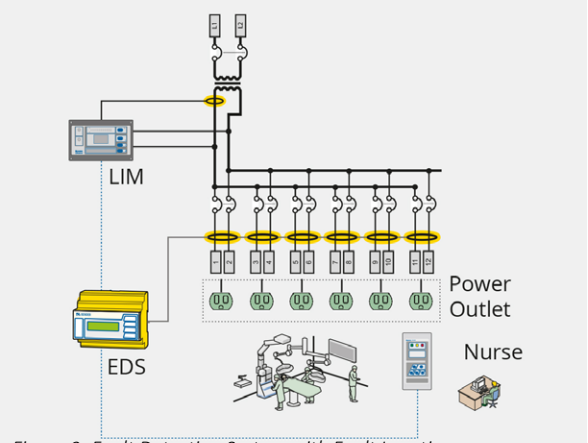

Figure 2: Fault Detection System with Fault Location

In addition to the ground fault location system, BENDER has developed remote solutions which enables the information of Isolated Power Systems and their associated devices to be monitored directly from a central location. The layout can be seen in Figure 3. When the EDS module is connected to a remote station, the maintenance team receives an alarm directly in their central office. The remote station indicates to the central office in plain text and/or graphical display which Building, OR/ICU, panel, and circuit is involved. Additionally, this information is stored in the device history for future use.

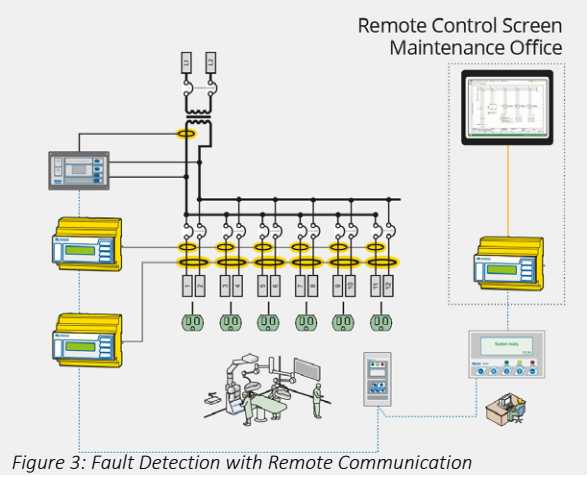

Figure 3: Fault Detection with Remote Communication

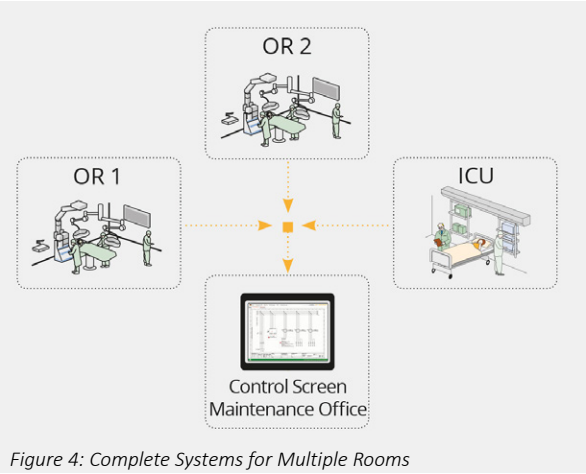

Figure 4: Complete Systems for Multiple Rooms

When utilizing different programming options, the faulty device will be directly identified and transmitted to the maintenance office. By receiving accurate information and pinpointing the fault location, the facility maintenance team gains increased efficiency. With BENDER fault detection system, the maintenance operation can be done in 15% of non-occupation rate without creating additional delays.

Upgrading your basic isolated power system with BENDER's fault location solutions offers a quick Return on Investment (ROI). Taking the example of an OR with 16 circuits connected, the cost to upgrade with a BENDER Fault Location System is equivalent < 2hs of OR down time.

Conclusion

By Implementing BENDER's fault location system you:

- Increase facilities' prestige by improving OR availability
- Positively impact clinical personnel retention due to increased system resilience
- Reduce the risk of OR closure due to ground fault search
- Reduce unexpected surgery cancellation due to OR availability
- Reduce power outages by promptly rectifying the first fault condition
- Reduce Biomed/maintenance staffing and overtime
- Have a quick return of investment with low out of pocket cost

IMPACT OF A GROUND FAULT IN OR/ICU

Main Risks	*With Basic Isolated Power Systems in OR*		***With Bender Inc. Fault Location System***	
	Delay Impact	**Cost**	**Delay Impact**	**Cost**
Clinicians required with Over Current Protection Device (breaker) authorization	+	+	none	none
Maintenance team with fault search training	N/A	++	none	Bender Inc. training
Search for fault equipment	+++ (up to $17,760/day)	++ (additional resources to limit delay impact)	– (Instant identification)	+ (One-time investment of <$225/circuit)
Hospital Reputation	High risk of negative review if cancellation	+++	none	none

i « Assessing the Performance of Operating Rooms : What to Measure and Why ? », Hong Choon Oh, Tien Beng Phua, Shao Chuen Tong, Jeremy Fung Yen Lim ; Proceedings of Singapore Healthcare, Vol. 20, Number 2, 2011

ii « First-Case Operating Room Delays Patterns Acros Urban Hospitals of a Single Health Care System », C. M. Cox Bauer, D. M. Greer, K. B. Vander Wyst, S. A. Kamelle ; Journal Of Patient-Centered Research and Reviews, Vol. 3 Issue 3, 2016.

iii « Interventions to Reduce Intraoperative Costs : A Systematic Review », C. P. Childers, A. Showen, T. Nuckols, M. Maggard-Gibbons; Annals Of Surgery, Vol. 268, Issue 1, p.48-57, July 2018.