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Technical Paper: "Installation Considerations for Hospital Isolation Panel Systems and Associated Grounding Systems":

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Why is this paper's information essential?

Some basic design and installations practices for hospital isolation systems and grounding are being overlooked, resulting in newly installed systems that do not pass current NFPA and NEC acceptance tests. (See actual report at end of notice). This paper is current as of 12/5/2017

Several suggestions follow, which should assure compliance to the latest NFPA99 (Health Care Facilities) and NEC70 (The National Electric Code) and acceptable testing results on Hospital Isolation Power and Grounding Systems installations:

1) To **Consulting Engineers**, **equipment specification preparers**, **hospital administrators, purchasing departments**, and **installing contractors**: Hospital electrical equipment to be used in patient areas protected by Isolated Power Systems, whether to be hardwired or powered via cord and plug, whether purchased direct or through contractors, should be **specified: "for use on a Hospital Isolated Power System"**. This statement will require the equipment suppliers to provide: **a) Low leakage internal wiring of correct color (brown with stripe and orange with stripe), b) low leakage ballasts, c) low leakage transformers, d) NO SURGE PROTECTION (internal MOV's), e) and two pole-disconnecting devices on that equipment**. Specifying **UL approved** equipment is **NOT** enough. Standard UL equipment is constructed for a grounded electrical system. This equipment has higher leakage ballasts which will lower isolation system's impedance and will add Hazard Current to system when energized. The Isolated Power System's LIM (Line Isolation Monitor) will monitor all the connected equipment on its system. The equipment that has the highest Hazard Current are the computer monitors. The need to be specified to work on an Isolated Power System to pass the system impedance test.

2) To **consulting engineers** and **installing contractors**: review and understand the complete installation specifications required by the NEC70 Article 517, NFPA 99 code. Most specifications already clearly require

low leakage branch circuit wiring, dielectric constant 3.5 or less, XHHW-2 type, brown and orange (and yellow) color wire (with a stripe). Current NFPA codes require that this isolated power branch wire color be "striped, but not with white, gray or green stripe". Note the ground wire does not need to be lower leakage; THHN is fine for the ground wire. There are several manufacturers of reasonably priced acceptable XHHW-2, building wire. This XHHW-2 wire is just slightly more expensive than THHN, and most manufacturers and/or distributors can provide small quantities, 500 to 1000 feet. If the wire supplier or manufacturer has an excessively large minimum purchase quantity, or if price is more than 20% higher that THHN, then change suppliers.

3) Addition suggestions to **consulting engineers** and **installing contractors** to minimize the problems in the installation:

a) Minimize the total footage of secondary wire that is energized (make runs direct and short).

b) Minimize the number of circuits, with 10 to 12 circuits being preferred (16 circuits is the maximum per code but not recommended. Generally, do not put in more than 12 energized circuits per single panel isolation system except in small sized operating rooms. Almost all current OR's will need two isolation panels because 28 to 30 circuits are required for proper diversity. Single panel Isolation Systems in large operating rooms, with 16 isolated power circuits do not test well within NEC-NFPA required system impedance test, unless installation is done very carefully. This means that you should use multiple isolation panels, such as duplex isolation panels to provide the 28 to 32 circuits, in order to meet the system impedance requirement for each panel.

c) Do not wire out all the spare circuits that are provided in typical isolation panel. All that extra energized wire adds considerably to the system leakage. Some specifications require branch breaker panels to be filled with circuit breakers and wired out to ceiling junction box. This practice will cause excessive hazard current, and these specifications should be changed accordingly. If engineer or general contractor presses this PLEASE CALL YOU US.

d) Group the receptacles on the circuits, minimize energized wire length.

e) Minimize circuit diversity! Do not run circuit #1 to all four walls and then run circuit #2 to all four walls. This practice results in too much energized wire, and too low of a system impedance. System will not pass tests.

f) Use receptacle cluster modules with 4 duplexes each. Individual mounted duplex receptacles, installed every two feet around the perimeter of the room, often require too much wire. Minimized the total energized wire length.

g) Use bigger conduit and minimize conduit fill. A metallic conduit stuffed with wire has a high capacitive coupling to ground effect and a high hazard current (leakage). Typically use ¾" conduit for every two - 20 amp, 12-gauge circuit. AND do not specify or use 10-gauge wire for these 120 volt circuits. This wire impedance is NOT the impedance we are referring to.

h) Do not tightly bundle (tie-wrap) all isolated power branch circuit within isolation panel. This adds 8 to 10 micro-amps of hazard current.

i) Do not use any wire pulling compound in conduit. This is a code requirement; even talcum powder has shown to draw moisture into conduits, decrease system impedance, and increase hazard current (leakage).

j) Minimize the number of elbows, and minimize the pulling force required for installing wire.

k) Balance the two conductor lengths of branch lines one and two. Do not run circuits as a 120/240 three-wire system. Do not use two "hot" conductors to several locations and only a single "return" conductor or "Home run" back. This shows up on the circuit leakage test.

l) Even though there is **NO NEUTRAL in a hospital isolated power system; since** both lines are hot to only to each other, (just like a 240-volt and 480-volt single phase systems), there is an added special consideration. Because the terminals on a 120-volt outlet are differentiated by color: hot (Brass) and neutral (Silver): the code requires the contractor to wire the Orange (striped) conductor to Silver terminal of the receptacles "as though it was the neutral conductor". The orientation of the panel wire color determine what is wired to what. The Orange (striped) conductor leaving the branch breaker must be connected to the corresponding breaker pole (Orange bus) and to the 120-volt receptacle's (silver) screw connector point designated for the grounded conductor. This must be checked during startup and certification. This orientation has become a MAJOR problem. Electrician are trained to utilize a BOY (Brown-Orange -Yellow) coding for 480. Many jobs have been branch wired with the first pole being Brown, even though it was designated Orange by isolated Power panel manufacturer. THIS COULD MEAN THE WHOLE JOB WOULD NEED TO BE RECONNECTED BOTH AT RECEPTACLES AND AT BREAKERS.

m) Because the electrical system wiring is identical to 240 single-phase, except for voltage, two pole disconnecting device within or directly before hard wired electrical equipment must be used in order to safely disconnect equipment. This means that 2 pole branch breakers are used to feed the 120 branch circuits. This also means the simple plug in circuit wiring testers do NOT work correctly if you just plug them into an isolated power system. To get them to work and indicate properly, temporarily jumper the orange conductor to a ground point. The LIM will alarm but the plug-in testers will now show correct wiring (**if the orange wire was wired to neutral terminal**).

n) Make sure to use the NEC 70 required type and color of conductors. The NEC 517-160 requires dielectric constant of 3.5 or less (XHHW-2): **Brown** (striped) and **Orange** (striped) color identification (and **Yellow** (striped) for 3rd phase).

o) Do not connect overhead general ceiling lighting to rooms isolated panel; the Hazard Current is too much. Lighting fixtures that does not extend down into room area does not get connected to isolated power. This also applies to incandescent lighting ceiling mounted. However, the surgery light that swivels down into patient service area does need to be on iso power.

p) Do not use or specify **three phase isolation panels to feed single phase loads**. This is a misapplication of these systems and are nothing but trouble. The isolation systems, being monitored by the LIM need to be balanced.

o) Do not use or specify any TVSS devices, surge-protected outlets or surge protected outlet strips on an isolated power system. The MOVs, that protect power system from surges, have extremely high leakage to ground. The Isolation transformer will provide a great deal of surge and noise filtering protection by itself. If you must, use system surge protection only upstream of Isolation transformers. This surge protected issue frequently comes up with time of day clocks and elapsed time clocks mounted in the OR when powered by isolated power systems.

4) Grounding and bonding issues:

a) A RGP, (Room Grounding (bonding) Point), sometimes called a RGM (Room Grounding Module), is required by code. This grounding point usually is mounted within the isolation power panel, making it unnecessary to specify a stand-alone 'Room Grounding Point" ground module in the room. Additionally, most standard Receptacle & Ground Jack Modules and Ground Jack only modules can be ordered with this RGP ground bus mounted within the modules. A typical OR room has one or two Isolation Panels and four (4) receptacle modules (one per wall), so there is plenty of grounding (bonding) points available.

b) The NFPA and NEC codes have removed the term "Equipotential Grounding from their text. The grounding results are more important than the amount of green wire used. The code NPFA 99- 2012, #6.3.3.1.1.2 and #6.3.3.1.1.3 advises that some items that do not need to be intentionally grounded are "Small, wall mounted, conductive surfaces, not likely to become energized, such as surface mounted towel and soap dispensers, and large, metal conductive surfaces not likely to become energized, such as windows, door frames, and drains." This does mean though, that you do need to intentionally ground any conductive surface areas that are "likely to become energized, within the patient service area", such as HVAC vents, metal shelving and cabinets that have built in lighting and/or that contains or shelves electrical equipment, such as defibrillators, physiological monitors, and metal door frames that have electric controls such as openers.

Please note that all electrical equipment should be grounded via the green wire pulled with the power conductors. This includes the overhead lighting, any articulating arm service modules, and x-ray viewer, monitors, receptacle and grounding modules, and alarm modules. None of this electrical equipment needs to have another external green wire attached to it. The ground testing equipment now allows all this grounding to be checked via external probes for both voltage and impedance per NFPA requirements. However, the design engineer does have last say on what they want grounded, so read and follow their specifications.

c) Additional comments: **NPFA 99-2012 #6.3.2.6.2 test for the system impedance test requires 200,000 ohms or greater, for the isolation panel, transformer, LIM, circuit breaker panel, branch circuit wiring and receptacles**. The test does not have to test the hard-wired lighting fixture equipment. It is perfectly acceptable and even recommended to turn off or disconnect this fixture equipment to lower system leakage and increase the wired system impedance. The uses of plug connected fixtures or using a TWO pole-disconnecting switch makes testing much easier.

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Actual report of problem job: **TESTING AND INSPECTION RESULTS:**
(Do not let following happen to your job.)

The hospital's electrical isolation system(s) for the above installation, does **not** conform(s) to the **System Impedance Test** of 200,000 ohms or greater. This installation does **not** meet the requirements of, **nor** passes the tests required by, NFPA-99 and the NFPA-70 the National Electrical Code Article 517. The 8 position X-ray film viewer by X&X, the Single X-ray film viewer X&X Model # XXXX, the XXXXX Telecom Articulating Arm Modules, and XXXXXX Chromophore Exam light system with dimmer package, all added excessive leakage to the isolation system. **None** of this equipment has local two pole disconnecting devices installed, which could have been used to temporarily disconnect equipment to lower the system leakage and increase system impedance for testing as permitted by NFPA and NEC. Additionally, the isolation panels are **16 circuit panels** in which 14 circuits are being used. Two and three spare circuits were wired in, and terminated in, junction boxes in the ceiling, which added considerable leakage to the system. Finally, within the Isolation Panel itself all the brown and orange low leakage wire for branch circuit wiring was tightly bundled together and tie wrapped along one sidewall of the panel. While this makes for a neat installation it added over 30 micro amps of leakage to the system.

Recommendations:

The **operating rooms need to be rewired per NFPA & NEC code**. Two pole-local disconnecting devices need to be installed for every piece of electrical fixture equipment. The viewer fluorescent ballasts need to be changed to low leakage ballasts or rewired from a separate grounded panel on a GFI breaker. The electrical equipment mentioned needs to be returned to supplier and have low leakage internal wiring installed to replace the existing high leakage internal wiring.