The Equipment Grounding System (EGS) As An Effective Bonding Topology for Telecommunications Environments

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***Abstract* -- Being provided an adequate telecommunications bonding infrastructure is one of the primary concerns for telecommunications cabling designers and installers for new and existing installations. Though not considered a safety ground where ground fault current is concerned, the telecommunications bonding infrastructure has importance where the components are intended to equalize potentials in the event of lightning, electrostatic discharge, electromagnetic interference, and other transient events that may be imposed on it, or within telecommunications spaces.**

Very recently, several telecommunications design groups with varying responsibilities for data center, military encryption, and commercial facilities have explored feasible options in providing an equipotential plane for their telecommunications bonding infrastructure, especially in locations where exposed metal frame of the building is not available; the most prominent of these options being the use of the ac equipment grounding conductor (EGC) system due to the abundance of metallic surface area utilized for the ac premises wiring system.

This paper is intended to present field-testing data and draw technical conclusions from same as to whether the equipment grounding system (EGS) is viable as an alternate bonding infrastructure plane that can achieve the same effect as the standard practices in place today.

***Index Terms*—Bonding, earthing system, equipment grounding system, equipotential plane, impedance, resistance.**

INTRODUCTION

Recent updates and inclusions to industry standards for telecommunications have made significant strides in enabling these personnel to pursue varying topologies in which to achieve an equipotential plane for telecommunications equipment.

One significant change, incorporated recently by the Telecommunications Industry Association's (TIA) 607C has been the acceptance of the metal frame of the building being used as a bonding conductor in lieu of insulated copper bonding conductors run between floors or between telecommunications spaces on the same floor. Acceptance of this design option is made when verification that the metal frame of the building is effectively bonded to the ac electrical system testing methods, as prescribed in [6], [8], and [11].

In cases where a bonding design topology is incorporated for a site, the survey team wanted to verify that a properly installed and maintained EGS can enhance the standard bonding topologies.

This paper reveals the impact of an improperly installed or maintained EGS in relation to electronic equipment, with and without a telecommunications bonding topology in place. See Figure 1.

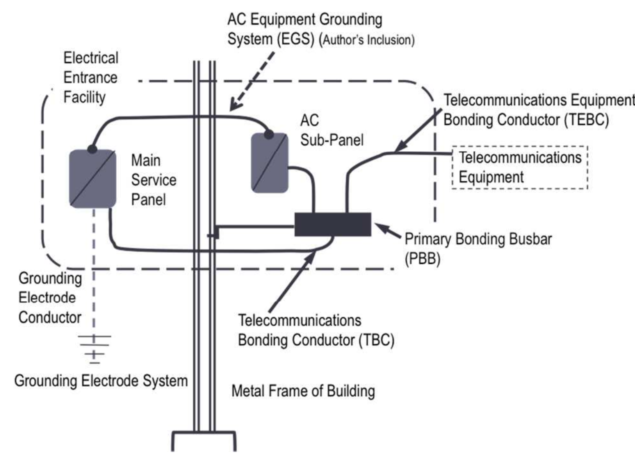

Figure 1

Lastly, the engineers and installers at many of these test locations explored various enhancements to the mechanical infrastructure of their telecommunications rooms, such as utilizing industry approved star washers to maintain continuity between painted metallic surfaces.

BACKGROUND

The first reference to contemporary accepted bonding topologies appear in military standards written in an era where the use of an EGS was non-existent. The bonding topologies specified from the military standards have been adopted with little change over the course of time. The author of this paper could not locate any technical reference as to the viability of the bonding topologies once the EGS was commonplace other than the perpetuation and reference of the aforementioned military standards. Independent studies made reference to limited testing of the EGS to support the sole use of it; however, no significant data was presented.

Data collected for this report were made at twelve locations over two years across the United States, Japan, and Canada. These sites varied in building height (number of floors), number of telecommunications spaces, complexity of equipment, and site operation, including commercial and military/government. Some raised floor environments (e.g., data centers) were examined during the course of the studies to do determine the feasibility of using the conductive floor elements as a bonding plane for complex technical environments.

Table 1, below, shows the categorization of the sites that were inspected.

TABLE I
GENERAL INFORMATION OF TESTED SITES

Site	Metal Frame of Building?	Multi-Floor?	TIA Bonding Topology?
A	N	Y/2	N
B	Y	N	Y
C	Y	Y/4	Y
D	Y	Y/5	N
E	Y	Y/107	Y (limited)
F	Y	Y/10	Y
G	N	Y/3	N
H	Y	Y/7	N
I	N	N	N
J	Y	Y/63	N
K	N	N	Y

Metering Interfaces/Procedures

The Two-Point Bonding Measurement was used during the course of these investigations to determine the quality of bonding with, and without, the bonding topology [11]. This test method was used to measure the bonding resistance between the metallic surfaces within the telecommunications or data center rooms for the test locations. Two types of meters were used to measure the quality of the bonding resistance

A. *Earth Ground Resistance Testers*

Three-terminal earth ground resistance testers are often used to measure the quality of a grounding electrode system, however, they are gaining popularity where continuity measurements are necessary for site bonding validation. Various manufacturers of these testers have the ability to nullify the presence of dc or ac currents that may plague the conventional testers (volt-ohm-milliammeters (VOMs)). The manufacturers of earth ground testers use proprietary circuitry that captures data at the frequency the test signal is generated, minimizing the influences of 60Hz stray current or their harmonic. Useful for basic testing, they had limited application for this paper's data collection where gathering of low milliohm or micro-ohm data was desired.

B. *Micro-ohmmeters*

These testers were the primary meter for the bonding resistance data collection of this paper because of their range in displaying micro-ohm readings.

Maximum Two-Point Bonding Resistance: 100 milliohms.

C. *Ground Impedance/Wiring Polarity Testers*

Ground impedance testers from three different manufacturers were used to measure the polarity of the 120VAC outlets. They were also used to verify correct wiring polarity as well determine the integrity of the connections along the 120VAC branch circuits.

Criteria:

Wiring Polarity – Correct Wiring and no N/G bonds at outlet;
Maximum EGS and Neutral Impedance – 1 ohm.

D. *AC and DC Amperage Measurements*

An important measurement that was made at all sites prior to bonding resistance/ground impedance testing was the measurement of ac and dc currents on bonding conductors within all rooms. The presence of amperage on any bonding conductor could likely impact both safety for the testing team and affect the metering instruments. A True RMS clamp-on ammeter was used in all circumstances.

Criteria:

Maximum AC current – 1A
Maximum DC current – 500 mA.

Equipment Grounding Conductor Impedance

The EGS is mechanically constructed for the electrical system, serving two main purposes, both of which relate to preventing personnel shock and fire hazards:

1. To maintain zero-volts on all equipment enclosures (metal surfaces) during normal electrical system operations.
2. To provide an intentional path for current during ground fault conditions.

The structural integrity of the EGS is primarily rigid steel or a composite, such as electrical metallic tubing (EMT). Only general studies have been done on the impedance of the conduit, the most recognized being the works cited in [3] and [5], however the results appear to be generally accepted as accurate.

The measured impedance values demonstrate that the overall impedance of the EGS raceway/conduits are consistently low enough to provide an effective grounding path as required by [12]. In most cases, single runs of conduit can be utilized to distances approximately four hundred feet without degradation in its performance as a ground fault current return path. When compared to similar conductors that are used for telecommunications bonding (predominantly #6 AWG conductor), the differences in resistance are noteworthy.

An added component to this study is the addition of bare or insulated conductors that supplement the steel or metallic conduits. The additional surface area provide by the metallic conduit and internal conductor has greater conductivity than the surface area provide by a #6 AWG bonding conductor, used in most telecommunication spaces. The comparisons to the surface area are shown in Table 2, below.

TABLE 2
Equivalent Resistance of Metal Conduit
And Copper Conductor Sizes

Size of Conduit (diameter/inches)	Ohms/100'	Equivalent Copper Conductor (AWG)
½	0.08	2/0 AWG
¼	0.0605	4/0 AWG
1	0.0385	300 kcmil
1 ¼	0.03	350 kcmil
1 ½	0.0258	500 kcmil
2	0.0198	600 kcmil
2 ½	0.0119	1000 kcmil
3	0.0088	1250 kcmil
3 ½	0.00752	1500 kcmil
4	0.00598	2000 kcmil
5	0.00473	>2000 kcmil

The studies presented in [3] conclude that parallel circuits will be present in ac electrical systems, where conduits of varying lengths will be incorporated as ac power is distributed through the building. For this reason, the overall impedance of these paths, for any frequency range, would be less than that of single conductor paths, regardless of conductor size, presented in telecommunications bonding topologies. It is believed the benefit stems from fewer instances where unwanted resonance conditions for parallel conduit (and other hardware) connections may exist. In comparison, elevated instances of parallel resonance can often be encountered where high frequency events are imposed on single conductor paths with no alternative paths for the various frequency components to dissipate appropriately.

SITE INVESTIGATIONS

The investigative team split the sites into two different categories: those with the [11] bonding topology and those without. These sites are denoted in Table 1 as with either a 'Y' or 'N' in the last column.

E. Sites with TIA-607C Bonding Topology

The sites in this category had an intentionally designed and constructed system of bonding conductors that were emulated from the TIA-607 standard. This includes the use of the following:

- Telecommunications Bonding Conductor (TBC): The bonding conductor that is intended to bond the telecommunications bonding infrastructure to the ac electrical grounding system.
- Primary Bonding Busbar (PBB): A busbar that serves as the central attachment point between the overall building electrical grounding system and the telecommunications bonding infrastructure.
- Secondary Bonding Busbar (SBB): A busbar that provides connectivity for individual rooms to connect to the overall bonding infrastructure as well as all components in the room.
- Telecommunications Bonding Backbone (TBB): A conductor that connects the PBB to SBB's in other rooms.
- Telecommunications Equipment Bonding Conductor (TEBC): A conductor that provides a bonding connection between equipment racks (or cabinets) and the PBB or SBB.

F. Sites Without TIA-607C Bonding Topology

These sites utilized the EGS system as their primary means for bonding, however, many of them had a conductor connection between a busbar located within the room and the ac electrical service or nearby panelboard. These conductors were not labeled as TBC's. Additionally, there were bonding conductors that served as TEBC's but not known as such.

TESTING PROCEDURE

The order of testing undertaken by the survey teams was with a concern for both personnel safety and useable data. In addition, any removal of conductors or connections as noted in the steps below, required the use of licensed electrical personnel. The process for meter testing followed the recommended procedures in [6] and [8].

1. Measure AC/DC Amperage.
2. Wiring polarity/ground impedance measurements to verify correct wiring polarity and verify the integrity of the connections and correct same, if possible.
3. Removal of TBC from the Primary Bonding Busbar (PBB) for the room.
4. Two-Point bonding resistance measurements

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between AC subpanel EGS and equipment racks.
5. Removal of TEBC's, where applicable.
6. Two-Point bonding resistance measurements between AC subpanel EGS and equipment racks.
7. Removal of ladder tray bonding connections between sections.
8. Two-Point bonding resistance measurements between AC subpanel EGS and equipment racks.
9. Reconnect all bonding conductors.

Licensed or otherwise-qualified electrical maintenance personnel performed removal and re-connection of all bonding conductors.

AMPERAGE/WIRING POLARITY MEASUREMENTS

Table 3 lists the sites that had exhibited current flow on their bonding conductors as well as any branch circuit wiring deficiencies in the branch circuit wiring. Coincidentally, the sites that had high current values or wiring issues were experiencing ongoing problems related to lightning or equipment performance issues. Extensive testing at the sites revealed wiring issues directly contributed to the ac current flow. Eventual correction of the wiring issues reduced or eliminated the amount of ac current so on-site testing could commence.

TABLE 3

Site	AC/DC Current?	Wiring Polarity OK?
A	N	Y
B	N	Y
C	Y	N
D	Y	N
E	N	Y
F	Y	N
G	N	Y
H	N	N
I	N	Y
J	N	Y
K	Y	N

Amperage/Wiring Polarity Testing Conclusion:
AC and DC current measurements on individual bonding conductors at all Primary Bonding Busbars and Secondary Bonding Busbar should be made mandatory for telecommunications personnel. Current measurements will:
1. Help uncover suspect areas where unsafe conditions exist and the appropriate personnel can be engaged to correct them.
2. Be instrumental in uncovering issues related to DC current (e.g., corrosion).
3. Validate other test instrument's indicated wiring conditions.

Wiring polarity and impedance measurements are crucial to pinpointing wiring condition that contribute to the malfunction or perceived voltage quality issues in telecommunications spaces.

SITE BONDING MEASUREMENTS

Tables 4 and 5 present the results of bonding measurements with and without additional conductors that are itemized in [11] as potentially suitable components. This included the bonding resistance measurement at equipment locations without a bonding connection between the room's bonding busbar referencing connection (e.g., ac panelboard) and the room's busbar. This data is presented in Table 4.

TABLE 4

Site	Bonding Resistance w/TBC (or similar) Connected	Bonding Resistance w/TBC (or similar) Removed
A	8.6mΩ	8.6mΩ
B	12.8mΩ	16.2mΩ
C	2.6mΩ	3.0mΩ
D	N/A	N/A
E	560μΩ	560μΩ
F	900μΩ	1.36mΩ
G	N/A	N/A
H	3.3mΩ	3.5mΩ
I	10.5mΩ	10.5mΩ
J	710μΩ	710μΩ
K	1.1mΩ	1.6mΩ

Additionally, resistance measurements were made between rack-mounted equipment frames and the metallic surface of the racks to determine the bonding integrity of the mechanical hardware without the supplementary bonding conductors used to bond equipment racks to the busbar (TEBC) or the conductors used to bond ladder tray sections that do not contain ac circuit conductors. This data is presented in Table 5.

Bonding Measurement Testing Conclusions

Data comparisons between the EGS with, and without, a TIA conductor-type bonding topology of a telecommunications space or floor are nearly the same. Small increases in the bonding resistance may still exist without the topology prescribed in [11]. The increase in resistance is deemed negligible.

Further information on the general findings of the sites can be presented in the following section.

TABLE 5		
Site	Bonding Resistances w/TEBC's Removed	Bonding Resistance w/Ladder Tray Bonding Removed
A	9.3mΩ	9.4mΩ
B	18mΩ	22mΩ
C	7.6mΩ	9.0mΩ
D	1.01mΩ	2.0mΩ
E	2.53mΩ	5.6mΩ
F	5.14mΩ	7mΩ
G	1.06mΩ	3.4mΩ
H	4.2mΩ	7.8mΩ
I	10.6mΩ	12mΩ
J	711μΩ	840μΩ
K	1.8mΩ	2.2mΩ

SITE SPECIFIC DATA

G. Site A

Of all sites tested and presented in this paper, this was the oldest site (built in 1867) but had a significant communications infrastructure that supported over one hundred users. It did not utilize a TIA bonding topology. There was no TBC installed for the site nor were there Telecommunications Bonding Backbones (TBB) between rooms or floors. Four rooms were tested.

The maximum length for any of the 120VAC outlets EGS's was approximately one hundred thirty feet but many junction boxes were used to distribute power. The bonding resistances with or without any of the additional conductor bonding were far less than the recommended maximum value. No value exceeded 9.4 milliohms. The survey team determined that the parallel resistances due to the multiple branch circuits and the abundance of metallic conduit likely contributed to the low readings.

Site Conclusion: The lack of an effectively grounded metal structure was not a factor and that the EGS components were sufficient in providing a low impedance bonding infrastructure.

H. Site B

Three rooms were tested at this location, which utilized a TIA bonding topology. The metal frame of the building was used but not effectively bonded to various busbars. However, a minimum of ten 120VAC circuits was located in each room. These rooms also had two ac 120/208VAC subpanels. Electrical junction boxes contributed to the very low readings measured via two-point bonding resistance measurements.

Site Conclusion: Subsequent bonding to the metal frame of the building at this facility lowered the resistance values between all connections to less than seven hundred micro-ohms.

I. Site C

Measured ac current value of 3.2 amperes at two bonding conductors indicated that an unsafe condition existed in this data center room. Further testing and examination found that one of the junction boxes, which fed a number of isolated grounding-type receptacles had neutral and ground bonded. This outlet was on a string of eight outlets fed from a 20-ampere-rated circuit breaker in a power distribution unit (PDU) and may have been the cause of ongoing problems at this site.

Once corrected, the bonding connections between rooms were removed for testing. Bonding resistances did not increase significantly despite the lack of bonding between rooms.

Site Conclusion: It was evident that the presence of ac current due to an improper wiring condition in the ac power system was propagated on the equipment rack and other bonding infrastructure components within the room. In spite of this finding, bonding resistance measurements conclude that the metallic infrastructure was sufficient in providing an effective bonding plane.

J. Site D

The bonding infrastructure measured out to be above satisfactory. Testing at this site revealed the presence of ac current on certain bonding conductors, yet the direct cause or path for the high readings could not be determined. Physical examination of the EGS uncovered two outlets that exhibited ground impedances greater than 1 ohm. Subsequently, electrical maintenance personnel uncovered numerous loose connections along the hot, neutral, and equipment grounding conductor paths, which may have contributed to high impedance readings.

Site Conclusion: The high impedances readings on the EGS did not affect the bonding infrastructure resistance, which can appear to be a good result. Unfortunately, like Site C above, it was a demonstration that a proper installed telecommunications bonding infrastructure cannot, by itself, compensate for a poorly maintained EGS, which would personnel safety and component integrity.

K. Site E

This high-rise building established all telecommunications bonding via the metal frame of the building with the exception of two floors dedicated to a government entity, which utilized a conductor bonding topology in addition to the metal frame. Nearly all telecommunications rooms were found to have bonding in the micro-ohm range, even with the customer-designed TIA bonding topology.

Site Conclusion: It was difficult for the survey team to find bonding resistances that exceed 1 milliohm due to the structural integrity of the building and the mechanical integrity of the electrical installation.

L. Site F

All bonding resistances at this site were measured to be well below the recommended maximum values of telecommunications standards, particularly without the connection via the TIA bonding topology. With the connection provided by the Telecommunications Bonding Backbone (TBB) conductors removed, the EGS for each of the rooms was found to be adequate in maintaining an effective bonding infrastructure.

The survey team encountered ac current levels on certain bonding conductors that could be traced to a 120VAC outlet that had the neutral and EGS conductors reversed. This outlet was in a series of nine outlets on a branch circuit. Though the ac current did not affect the bonding infrastructure, the telecommunications bonding integrity was helpful in helping to locate the current flow and, though dangerous, could not otherwise had been detected.

Site Conclusion: Low-resistance bonding could be achieved with, or without, the recommended TIA components. As with Site C, the presence of ac current was indicative of an improper wiring condition at an outlet. Likewise, some of the ac current on the EGS will travel along the bonding infrastructure due to the interconnectivity of all metallic components, including the ac cord and plug-connected equipment. AC current on bonding conductors should alert installers/investigators to a dangerous wiring condition that warrants further investigation.

M. Site G

This building consisted of all masonry with little or no accessible building metal frame. All bonding resistances at this site were measured to be well below the recommended maximum values of telecommunications standards. Again, the EGS for each of the rooms was found to be more than adequate in maintaining an effective bonding infrastructure.

Site Conclusion: Low-resistance bonding could be achieved with, or without, the recommended TIA components.

N. Site H

This building owner utilized metal frame of the building as their bonding mechanism. All connections were found to be of sufficiently low resistance. Many loose connections were encountered in the ac branch circuit wiring during the course of the investigation but were located and tightened.

Site Conclusion: It was not necessary to install additional bonding infrastructure to achieve an equipotential plane within any of the rooms. However, the lack of maintenance for this customer created perceived voltage quality problems and resulted in other discussions to explore additional bonding needs. Since their loose connections were identified and corrected, customer has been error-free.

O. Site I

This site had three telecommunications rooms of varying distance from the Main Electrical Service Entrance for the building. These distances were:

1. Room A – 25 feet.
2. Room B – 85 feet.
3. Room C - 170 feet.

The site had complete reliance on the EGS as their sole bonding mechanism. The building owner engaged an electrician for the occupant on a bi-annual basis for the ongoing electrical equipment maintenance.

Site Conclusion: It was not necessary to install additional bonding infrastructure to achieve an equipotential plane within any of the rooms. A properly maintained EGS only enhanced the integrity.

P. Site J

Similar to Site E, above, the telecommunications bonding for this building was achieved via metal frame of the building. All telecommunications rooms were found to have bonding in the micro-ohm range, particularly in rooms that were small 10’ x 10’ spaces that were fed by 120VAC circuits with ½ inch conduits.

Site Conclusion: Bonding resistances did not exceed 800 micro-ohms due to the structural integrity of the building and the mechanical integrity of the electrical installation.

Q. Site K

This site, over ten years old, employed the recommended bonding topology contained in TIA-607. The end-user complained that there were too many instances of premature component/hardware failure within their data infrastructure and placed suspicion on the bonding infrastructure. Bonding resistance measurements by the survey team determined that all bonding infrastructure components were installed with and exhibited low resistances.

Further examination, however, revealed numerous wiring errors at some of the outlets, including one immediate dangerous condition. Some of these wiring conditions resulted in significant ac current on the bonding infrastructures that were measured at the busbars within the rooms. This amperage created conditions that equated to low-level electrical shock conditions (but dismissed as electrostatic discharge) by some on-site personnel and visual arcing by others as they removed mechanical or electrical connections.

Site Conclusion: Based on the measured bonding resistances, the application of the bonding infrastructure was adequate in providing an equipotential plane. However, it was not enough to compensate for the lack of maintenance in the branch circuit wiring or other aspects of the ac electrical system. Subsequent changes within the premises wiring corrected the issues experienced by this customer.

X. Summary Of Testing

Based upon the preliminary research and collected data obtained during the course of testing at the above sites, the conclusion by the authors of this paper are the following:

1. The sole use of a properly installed and maintained EGS demonstrates the same level of bonding quality as those desired by the IEEE or TIA practices, particularly where those designs are not economical or practical to achieve.
2. The 'cage effect' of parallel EGS paths throughout a distributed electrical system promotes low impedance continuity for all scenarios encountered by the team and many of those modeled via historical data in [2]. It is imperative that the EGS be tested for its integrity as well as the verification that dangerous wiring conditions do not exist within telecommunications spaces, particularly where NOT testing could result in unwarranted or costly additions/changes in the bonding infrastructure.
3. The current design practices set forth by the recently adopted TIA-607C may be adequate in equalizing voltages in the low frequency spectrum if the EGS is installed per the minimum requirements of the National Electrical Code®.
4. Whether a TIA-designed bonding topology is incorporated or not, the EGS plays a critical role and should be tested and maintained periodically. In spite of a considerable telecommunications bonding infrastructure, poor quality connections within the EGS will increase the systems exposure to personnel/fire safety issues under phase-ground fault conditions, process disruption if exposed to electromagnetic interference, and component destruction/degradation during lightning conditions.
5. Tracking the integrity of connections over a predetermined period of time by site personnel can assist in incorporating predictive analysis on connections that may become loose. The scope of this paper did not include acquiring enough data over time to make the determination on how often inspections should be made but standard practices by Quality Assurance teams.

XI. Additional Observations

Additional collected data and technical conclusions, which were extraneous to this report, lend merit for consideration to incorporate other bonding options to telecommunications designers and installers based of other testing made at these sites. The findings suggest the following:

1. The removal of paint on adjoining sections of cable tray where they are bracketed provides low resistance and continuity, which is equal or greater to a #3/0 or greater conductor, thereby disqualifying the need for drilling for bonding straps between cable tray sections. In some cases, the removal of paint between sections equated to the same resistance as that for a 500-kcmil conductor.
2. The use of bonding straps between rack-mounted end-use equipment and the internal rack busbars is superfluous if the equipment is securely bracketed to the equipment rack with appropriate hardware (e.g., star washers). In spite of this team's finding, the installation requirement of the equipment manufacturer or internal wiring requirements would be the final authority.
3. Equipment racks that contain ac-powered or dc-powered equipment securely mounted to their frame need no additional bonding. If desired, then equipment racks need only be bonded to the cable tray if the cable tray is bonded in the manner described in **(1)** above.
4. Raised flooring within data centers have the necessary conductivity and surface area to allow for an equipotential plane, regardless of the floor size (square footage). This and other studies conclude that the measured resistance of the standard 24-inch x 24-inch floor tile might be higher than the design model expectation of 350 micro-ohms, with a range between 680 micro-ohms to 2 milliohms. Angular velocity of a transient waveform may increase the impedance of the floor but models indicate that the impedance value would be significantly less than the industry-desired 100 milli-ohms dc resistance required for effective telecommunications bonding.
5. It should be noted that the intended use of copper conductors and straps underneath a raised floor might further reduce the impedance of the floor where equalization with higher frequencies may be a concern. However, the measured resistance of raised flooring with, and without, the straps varied only by 75 – 125 micro-ohms. Though there is evidence to support the use of copper straps, the findings in this

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papers investigations support the sole use of the raised floor where conductivity across the gradient of the floor can be verified. However, there is no study that definitely covers the effects in comparison between the two. Further study is necessary here.

It should also be noted that the data center environment's bonding infrastructure can be negatively impacted where the lack of a properly installed and maintained equipment ground system exists.

Conclusion

Telecommunications bonding topologies can be as varied and dynamic as the equipment that resides within it. To date, few technical papers have dedicated the effort to determine how, and when, designs are implemented and how effective their result may be. This paper concludes that the EGS plays a significant role in establishing an effective bonding infrastructure as well as being more than adequate even if it is the only bonding mechanism available.

Recommendation

It is recommended that the chapter in [8] be written so as to provide an engineering design option to the sole, but outdated, bonding and grounding infrastructure practices being used by the telecommunications industry today. Since telecommunications bonding practices are not considered enforceable, the use of the word 'standard' implies that all designers could rely on their use based on updated, relevant site data. On the contrary, the use of a telecommunications bonding and grounding infrastructure is only effective if the EGS is intact and maintained.

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