Protection Considerations for Telecommunications Network

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Abstract

For the majority of the last century, single service fixed-line based networks were the primary means of communications. Over the past few decades, we have seen tremendous change to the traditional fixed-line model including the introduction of wireless networks and a shift in focus from single-service to multi-service networks. These newer multi-service networks are designed to provide broadband via both fixed-line and wireless connections. All of this rapid change has resulted in very complex network management organizations and safety issues that are distinct to each network type. This paper will provide a survey and discussion of the safety issues that relate to both fixed-line and wireless networks. It will examine how the infrastructure service model is drastically different between traditional fixed-line service providers and wireless service providers. It will explore issues and regulations relating to buried telecommunications plant. Finally, it will also review safety issues that relate to optical cable and fiber optic networks.

Keywords- Telecommunications, Safety, Confined Spaces, Turf holders, Fiber Optics, Fatalities, Cellular Towers, Utility Poles.

I. Overview: Different Service Models for Different Networks

Telecommunication cables including fiber, coax, and twisted pair are used in both hard line and wireless applications. In traditional hard line systems, the transport cable maintains a connection from the head end of the network all the way through the end user premise. This is true no matter what form of cable is being used. In a wireless system, the hard line cables are used for backbone transport of data and cell towers are erected to provide last mile connections. The two architectural structures require fundamentally different approaches to construction and maintenance, which results in a fundamental difference in how safety issues are managed.

There is a tremendous difference in how wireless communications companies manage their service and instillation work force. As the wire line industry is over a hundred years old, it is managed with a more traditional model of service workers who are directly employed by their respective companies. The workers tend to be organized into powerful unions, figure 1.

The wireless industry is dominated by a complex array of sub-contractors. This is due to multiple factors including relative newness of the wireless industry as well as the need for a flexible work force to be highly reactive to large build outs, figure 2. In wire line applications there are different issues that affect metallic conductors such as twisted pair versus optical cables. There are also different issues that arise from working with Arial applications of cables versus those of buried applications. Section II gives information about Fixed-lines safety issues. Section III discuses Wireless Safety issues. In Section IV, we discuss Optical Safety Issues.

Figure 1. The wire line industry

Figure 2. The wireless industry

II. Fixed-Lines Safety Issues

Utility poles were first used by Samuel Morse when he discovered that faulty insulation led to a failure in his telegraph. Modern utility poles can be made of wood, metal, concrete, or composites like fiberglass and recycled plastics. In all cases utility poles are designed to keep communications and electrical conductors elevated from the ground to avoid issues such as grounding, pedestrians, plants, animals, and malicious acts. Joint use poles are usually owned by one utility, which leases space on it for other cables. In the United States, the National Electrical

Code, published by the Institute of Electrical and Electronics Engineers (IEEE), sets the standards for construction and maintenance of utility poles and their equipment.
The joint use of utility poles by various service providers has a long history. This activity was much less complicated however, when the majority of end users were services by regulated utilities. In most cases this meant one “power” company and one “telephone” company. Before the age of cable television, those that had televisions used broadcast signals transmitted over the air. Over time, regulatory and market changes including the extensive deployment of cable television systems, the development of a competitive telecommunications market, the widespread provision of broadband communications services, and today the move toward citywide wireless networks have all resulted in increased demand for pole space. Each of these technical and commercial developments has had implications on pole attachments, in many cases prompting legislation, regulation, and adjudication [1].

This complexity has created safety issues for Arial applications. The focus of this study will be on telecommunications related accidents and fatalities, but by necessity the majority of the information available via sources such as OSHA reports pool information into the generic category of “utilities”.

There are two primary areas that are the cause of Arial plant injury and fatalities. Specifically the areas are falls and electrical shock. The higher percentage of fatalities in wire line applications is due to high voltage electrical shock. Although the voltage on metallic communication cables is not fatal, the close proximity of electrical lines means that there is a high probability of interaction between the workers, their equipment, and the high power lines. An example can be seen in recent case of Verizon technician Douglas Laliam who was fatally electrocuted while working on a joint use utility pole in September 2011. Verizon was cited with over $140,700 in fines for repeated failures to abide by critical safety rules. Specific violations included not providing grounding equipment, failure to provide high voltage gloves and helmets, lack of safety inspections and safety training [2].

For buried plant applications, the majority of danger relates to the dangers of working in confined spaces. These confined space hazards can range from an oxygen deficient atmosphere or exposure to toxic agents. Examples of toxic agents include plugging compounds and solvents. There is also the possibility of an explosion when working in proximity to natural gas lines. Finally there are environmental hazards that cannot be changed due to the structural nature of the confined space.

Confined spaces are areas that, by design, have limited openings for entry and exit, unfavorable natural ventilation that could contain or produce dangerous air contaminants, and are not intended for continuous worker occupancy. The formal definition of a confined space by Occupational Safety & Health Administration(OSHA) is found in the OSHA Regulations document titled Standards – 29 CFR: According to 1910.146(b) of the OSHA regulations "Confined space" is defined as a space that:

- Is large enough and so configured that an employee can bodily enter and perform assigned work; and

- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry.); and
- Is not designed for continuous employee occupancy.

Additionally CFR 29 1910.146, the OSHA General Industry Permit-Required Confined Spaces Standard, contains requirements for practices and procedures to protect workers in general industry who perform confined space work. The standard requires all employers, including telecommunications companies, to determine if their workplaces contain any confined spaces that meet the definition of a permit-required confined space. Permit-required confined spaces meet the following criteria.

- Contains or has a potential to contain a hazardous atmosphere,
- Contains a material that has the potential for engulfing an entrant,
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section, or
- Contains any other recognized serious safety or health hazard.

Therefore, all general industry employers, including telecommunications companies, must investigate all confined spaces to determine if working conditions are safe and healthful [3].

Confined spaces generally are considered by most to be manholes or sewers, but other communication industry areas that may be defined as a confined space include: splicing vehicles, garages, tunnels, loading docks, warehouses, and vehicle repair shops.

Confined space work may also involve work with and exposure to isocyanides contained in telecommunications plugging/splicing compounds. Commonly used plugging compounds include isocyanate compounds such as toluene diisocyanate (TDI) and methylene biphenyl diisocyanate (MDI). Of particular concern, inhalation to isocyanate products may cause nausea, vomiting, abdominal pain, and breathing problems. In addition, exposure may cause sensitization among affected workers to isocyanate products like TDI and MDI. In turn, further exposure may lead to workers suffering severe allergic reactions that could result in death. There is also the possibility of exposure to fumes from hazardous solvents or degreasers including carbon tetrachloride, trichloroethylene, trichloroethane, perchloroethylene, trichlorotrifluoroethane, and mineral spirits. The danger in using solvents in confined spaces varies according to the type of solvent and the duration and intensity of exposure [4].

Ergonomic hazards exist in confined space work. There is little that can be done to mitigate the hazards from the physical environment because of the design and structure of most confined spaces. There is also the nature of the work that has to be completed in the confined space that may pose hazards. These potential hazards include electricity, scaffolding, surface residues, and structural hazards.

While electrocution or electrical shock is not the major cause of fatalities in confined spaces, a study by The National Institute for Occupational Safety and Health (NIOSH) indicates it has been a factor in several injuries and deaths in confined spaces (www.cdc.gov/niosh/).

The use of scaffolding in confined spaces may contribute to accidents caused by workers or falling materials. Surface residues in confined spaces can increase the already hazardous condition of electrical shock and bodily injury due to slips and falls.

III. Wireless Safety Issues

In the United States, the wireless industry maintains a unique construction and maintenance model. Tower maintenance and construction is managed by large construction management firms referred to as “Turf Holders”. These construction management companies then find master subcontractors to divide the work. The master subcontractors hire and manage small locally owned subcontractors who are responsible for getting the actual work done. Because the work is getting split up by so many layers of subcontractors, there is intense pressure to keep costs down at the lowest layer. This pressure has resulted in lack of government oversight, lack of appropriate training, and numerous fatalities, figure 3.

Figure 3. Tower Fatalities 2003-2011 [5].

One of the reasons for the numerous safety issues, including 50 fatalities over the last decade, is the sheer number of cell towers in operation. As of a survey of the top 90 cell phone tower companies in the United States included: 99,930 with the top three providers owning 88,512 or nearly 89% of the market. The breakdown can be seen in chart. In the United States there are roughly 10,000 tower climbers or 9.3 towers per climber, table 1 below.

Where OSHA has a direct access to the wire line companies for enforcement, the structural environment in the wireless industry is completely different. With numerous layers of sub-contractors, the Wireless industry has many legal and organizational layers of obfuscation that exist between the decision makers and the workers. There is only one cited case where OSHA attempted to take legal action against a wireless carrier for the falling death of a tower subcontractor. The case was dismissed. In this environment there is little incentive for the carriers to make worker safety a high priority. There isn’t even a formal record that connects the carrier with the sub-contractor fatality. The turf vendors are insulated from government oversight from a similar model of sub-contractors under them [7].

Table 1 - Top Tower Owners

Rank	Tower Owner	Towers
1	Crown Castle	22251
2	American Tower*	21644
3	AT&T Towers	10312
4	SBA Communications	9290
5	T-Mobile Towers	8782
6	United States Cellular Co.	4802
7	Global Tower Partners	4150
8	TowerCo	3295
9	Mobilitie	2586
10	Verizon Wireless	1400
	Total:	88512

Note: *American Tower Corporation"s tower count reflects only domestic structures. The company owns additional towers internationally. Its most current total tower count is approximately 38,000* [6].

There is a stark difference between the structure of the American wireless industry and its safety record versus that of the rest of the world. International benchmarks are more difficult to obtain due to less communications between rigger companies and limited reports from English news media in foreign speaking companies. There were only 10 reported international tower related deaths between 2003 and 2008 where the US had 70. The case could be made that International deaths go underreported because of a less developed government reporting standards and the existence of government controlled media. There are two examples mitigate this argument. Between 2003-2008, there was only one reported fatality in Canada and zero in Great Britain. Both countries have free mass media outlets as well as extensive government reporting organizations.

These numbers would make sense if the US had seven times as many cell phone towers, but the actual number is dramatically different. According to the International Telecommunications Union (ITU), the United States cell tower portfolio is only 7% of the world's total [8].

One major point of difference between the countries is how they handle Subcontractors. In the majority of the world there are limited layers of subcontractors. In the instances where subcontractors are used, there is increased legislation here the authority holders are legally responsible for the health and wellbeing of the workers. As an example, in 2004 Canada introduced and passed Bill C-45 added Section 217.1 to the Criminal Code which reads:

"217.1 Every one who undertakes, or has the authority, to direct how another person does work or performs a task is under a legal duty to take reasonable steps to prevent bodily harm to that person, or any other person, arising from that work or task."

Bill C-45 also added Sections 22.1 and 22.2 to the Criminal Code imposing criminal liability on organizations and its representatives for negligence (22.1) and other offences (22.2) [9].

Like most service providers, US carriers typically set many of the parameters for work on cell sites; including deadlines, pay rates, and technical specifications. As mentioned earlier in this document, unlike Canada, US carriers are insulated from legal and regulatory liability for the fatalities due to the complex layering of subcontractors in the wireless industry. The parties that are liable tend to the smallest subcontractors. Although they can be put out of business because of a negative event such as a death, the owners of small business can quickly and easily go back into business under a different legal name.

An important point of note is that in the years between 2006-2008, there was significant growth in cell tower falling deaths with a high of 19 deaths in 2006 alone. Additionally, there were 6 cell tower deaths in 5 weeks in 2008 [10]. Since 2003 94 climbers fell to their death. The types of towers range from radio, television, microwave, and cell towers 50 of which are cell tower deaths, figure 4. Time pressure encouraged a practice called free climbing which is climbing towers without a fall arrest system in place. Free climbing is responsible for ½ of all deaths. Cell tower deaths outnumber all other communication tower deaths combined.

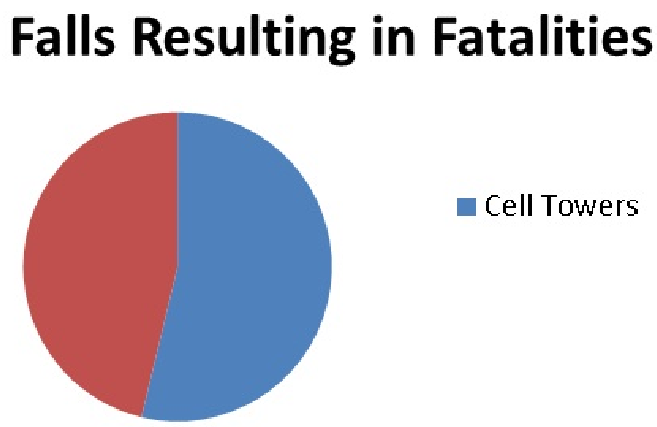

Figure 4. Falling Fatalities - All Falling Versus Cell Towers.

These events correlate very closely with AT&T"s purchase of Cingular and the intense multi-year network build out necessitated by the adoption of smart phones such as the iPhone. As the wireless industry scrambled to increase capacity more pressure was placed on the different contractor layers to meet tight schedules and margins. AT&T had the most build out activity and consequently had more fatalities than all other carriers in the US combined. As a result of the increases in fatalities, AT&T issued a construction stand down for a complete safety review. There isn't any clear evidence that the stand down modified the system in any discernible way, figure 5.

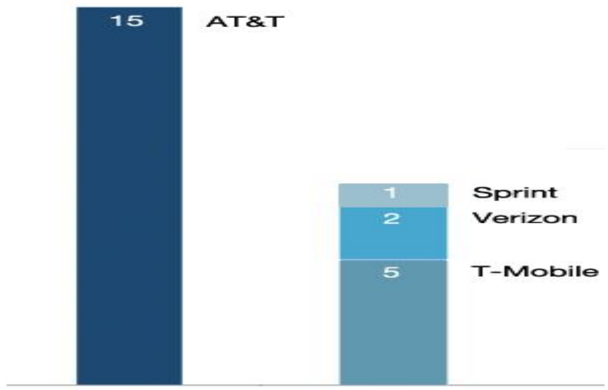

Figure 5. Fatalities by Service Provider [8].

IV. Optical Safety Issues

Beyond metallic wire line and wireless network connections there is another unique area that relates to safety issues and communication cables. Optical cables do not conduct electromagnetic energy so there is limited chance of electric shock when engaged in inside plant fiber optic work. There are some situations where there may be electrical hazards in outside plant applications. In all applications, optical cables carry very high intensity of laser light. Workers involved in fiber optic cable installation or repair may be at risk of permanent eye damage due to exposure to laser light during cable termination, connectivity and inspections. There is a polishing process involved in preparing the end of a fiber optic cable for connectorization. When extending a cable or mounting a cable connector, a microscope is typically attached to the end of the fiber optic cable allowing the worker to inspect the cable end to confirm its surface area is smooth and ready for the connector assembly.

Nearly all communication systems use infrared light to communicate, meaning the technician will not see any light. The fiber optic wavelengths used are adjacent to visible light in the electromagnetic spectrum which is why they can cause damage to an unprotected eye, figure 6.

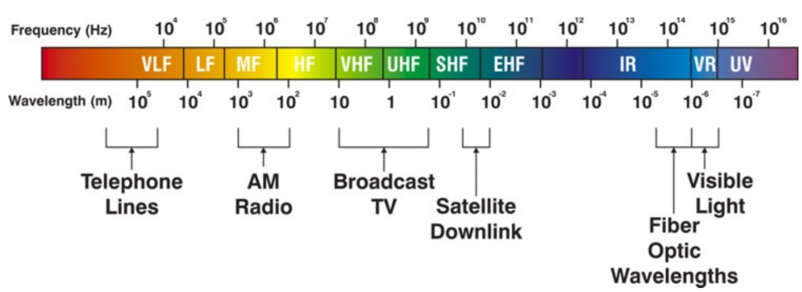

Figure 6. Electro-Magnetic Energy Wavelengths.

Another area of safety concern is the minute or microscopic glass fiber shards that result from working with fiber optics. These fiber scraps result from working with bare fiber. A “bare fiber” is a fiber that has had the primary coating removed, exposing the fiber’s glass surface. Many scraps are created as a result of the fiber splicing and terminating activity as a result of the cleaving process. The cleaving process is a process where a specialized cleaver is used to make a smooth break in the brittle bare glass fiber cable.

Bare fibers can easily penetrate skin and break off, causing micro-injuries. These injuries are very difficult to see and treat. When extracting with forceps the fiber scrap will may break off which will exacerbate the problem. These scraps can lead to infections in the skin, serious eye injury or internal injury from ingestion.

Another area of safety concern with optical fibers is exposure to chemicals. Some splicing or terminating procedures may require the use of adhesives, solvents, etc. The safety issues are the same as those that were cited with wire line connectivity.

The fibers themselves are dielectric, but if the cable contains any metallic parts at all, the cable is conductive and electrical shock becomes a safety issue. In many instances, there is a metallic member as a component of cable construction. These metallic components of the cable are used as strength members as well as a way to send a locating signal down the cable. The metallic members of fiber optic cables are regularly grounded in areas such as NIDS, Terminals, and Splice points. By the very nature of WAN networking these points may be miles apart which mean the technician may be working on the cable in an area where he becomes the most efficient path to ground for the electrical current [11].

In the same way that gas monitors are standard equipment for working in manholes and safety harness are mandatory for working on towers, optical fiber has mandatory safety procedures and equipment. Optical scopes reduce light output of a fiber. There are special handling techniques and tools for working with bare fiber. Optical cable safety procedures include always assume that a fiber is "hot" or lit; never point any fiber at any other worker. When working with a fiber that has a metallic member, best practices include always checking the cable for inducted voltage.

V. Conclusions

Safety issues are unique for wire line, wireless and optical cables. In all instances of modern telecommunications there are significant safety concerns. These concerns range from electrical and falling fatalities to permanent damage from lasers and incurable skin injuries.

There are some issues such as those relating to confined spaces and working with optical fiber where a greater focus on safety training would be an effective stop gap in reducing injuries.

The situation is much more complex when it comes to fatalities from falling from cellular towers. The fundamental makeup of the multi-level subcontractor structure creates a situation where safety focus continue to be diluted to the point where there is little to no interest in safety at the worker level.

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Biography:

Dr. Ibraheem Kateeb is the section chair of Central NC section and a Senior Member of IEEE with over 25 years of experience in academia and industry. He received his Ph.D. from NCA&TSU. He is currently at NCA&TSU as Assistant Professor of Computer Systems Technology Department. His current research is on power and green energy, electronics and control/robotics. In the last two years, he published more than 27 journal and conference papers and has many projects and grants in power, renewable energy and smart grid related issues. Dr. Kateeb was recognized as the recipient of Academic Excellent Award from CARTS International 2012 (Electronic Components Industry Association, ECIA) for one of his research papers.

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