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Applications

A Case Study

Lightning Protection for Denver Fire Station Extends Beyond its Property Line

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Think about Denver and you're more likely to picture ski trails than violent thunderstorms, but the Mile-High City is actually quite a "boom" town when it comes to severe weather. Denver experiences upwards of 50 mean thunderstorm days per year according to the Rural Utilities Service of the U.S. Department of Agriculture. That puts it on a par with most of the Midwest, the Middle South and even parts of Eastern Texas. The city's lightning season spans most of the summer, with boomers usually rolling in around noon and continuing into the night.

Worse yet, the Denver metro area is also situated on relatively level terrain, and any structures that protrude significantly above the surface – think antenna towers – are fair game for lightning strikes.

This brings us to the Cunningham Fire Protection District (CFPD), a regional fire district southeast of downtown Denver. It comprises some 14 square miles of unincorporated Arapahoe County and houses about 70,000 residents (2014 data). That's a lot of real estate plus a fair number of Coloradoans who might need emergency services one day even during a thunderstorm.

To serve that need, the CFPD operates three active fire stations, an administrative headquarters and a back-up station collectively staffed by 67 uniformed employees. In 2013, those firefighters and EMS personnel responded to more than 4600 fire, emergency medical services, hazardous materials, and public assistance calls. All of those calls were answered promptly, but that wasn't always the case in the past.



Figure 1. The Cunningham Fire Protection District's Fire Station No. 1 also houses administrative headquarters. From 1985, when the district bought the building, until 1999, electrical disturbances driven by summer thunderstorms caused increasingly expensive and hazardous and potentially fatal damage to communications systems.

David Markham, CFPD's Division Chief of Operations, is responsible for making certain that the district's equipment and personnel arrive where they're needed, when they're needed. He's been with CFPD since 1985, the same year the district bought the building that now houses its Fire Station No. 1 and district-wide administrative headquarters. **(Figure 1)**

It didn't take long for Chief Markham and his colleagues to notice that their new headquarters had some serious electrical problems. "Between 1985 and approximately 1999, the main station regularly sustained various types of lightning damage whenever thunderstorms came through. We didn't take any direct

hits, but there was considerable and potentially fatal damage to communications systems and hazardous damage to low-voltage systems like garage door openers (imagine fire trucks trapped indoors!), heating systems, telephones and, most important, our radio and computer systems.

"We did experience some actual communications outages during moderate to severe thunderstorms, when lightning knocked out our radio systems. Whenever that happened, we'd be forced to rely on our portable radios to maintain communications with the dispatch center; then we'd go back and repair the system to bring it back on line. Firefighters could tell when there was thunderstorm activity in the area and that lightning would strike nearby because they could actually hear and feel the lightning moving around the building! After that, the question was just what system is it going to knock out today?"

Time for a *Certified* Lightning Protection Contractor

Lightning damage soon got expensive: Markham estimates that "we were spending between \$8,000 and \$10,000 every year on repair and replacement, depending on which system was affected. But I don't think you can put a dollar value on outages. For us as an emergency response organization it's critical that we respond every *time*, so we had to stop the damage. Regardless of what problems we're having in our building, the public is relying on us to respond.

"We also had to stop the dollar losses. When we took a serious look at our repair costs and our ability to respond to emergencies, we decided that the best thing to do was to contact a lightning contractor. We put out an RFP and a couple of companies responded, including an electrical contractor who talked about general electrical bonding according to the NEC, which is different from what is required by lightning standards. We did not feel comfortable with that.

"We ultimately decided to work with Mr. Lightning, a 50-plus-year-old lightning protection contractor in Colorado Springs. They work with the specifications and materials listed by Underwriters' Laboratories and the National Fire Protection Association, and their employees are certified by, and maintain technical currency through, the Lightning Protection Institute. That's what we wanted.

"We visited Station No. 1 with Mr. Lightning, and, after a survey, they explained that the new system would include the basic elements of the NFPA specifications: making certain all high points on the building are protected with lightning rods, bonding all rods with a common conductor and installing (at least) four points of low-resistance, low-impedance ground to earth."

Specifically, the Mr. Lightning team designed and installed strike termination devices (the currently accepted term for lightning rods, Franklin rods and air terminals) at all high points on the structure, as well as all ungrounded, metallic equipment on the roof. **(Figure 2)**. They connected rods and equipment with neatly installed runs of 32-strand, 17-gage AWG braided copper lightning cable. Leads from those cables were, in turn, bonded to a ring of braided copper running around the periphery of the roof, and from there, four braided copper down-conductors were run along the exterior walls of the building, terminating at 10-ft driven copper grounding electrodes, establishing the four points of grounding (earthing) required by NFPA specifications. Where practical, down-conductors could be located near the building. **(Figure 3a)** In places where such areas were blocked by sidewalks or paving, electrodes were offset from the building accordingly **(Figure 3b)**.



Figure 2. Strike termination devices (lightning rods) are mounted on all high points on the Fire Station No. 1 roof, and on all ungrounded metallic equipment. All termination devices and equipment are connected with 32-strand, 17 Ga. AWG braided cable. The cables are bonded to a collector ring (not shown) running around the roof's periphery.



Figure 3. Where practical, 32-strand, 17-Gage AWG braided copper down-conductors were run directly to copper grounding electrodes near the building wall (3a, left). Where sidewalks or paving interfered, the electrode was displaced outward from the building wall and the cable extended to them (3b, right).

About that tower...

Located on the lot directly next door to Fire Station No. 1 and about 90 feet away, is a 200-ft-tall TV transmission tower dating to 1964. It remains in use by a low-power TV station and some cellular providers, but the fire station itself has never used it and has no equipment on it. (Figure 4)



Figure 4. A privately owned, 200-ft transmission tower stands on the property immediately adjacent to Fire Station No. 1. The fire station does not utilize the tower; however direct lightning strikes to the tower or induced currents in the tower during storms did affect low-voltage electrical systems in the station.

The tower was not entirely isolated from the station in that it was close enough to induce potentials in the short span of earth between it and the fire station. It is plausible that lightning energy from direct strikes to the tower and even electrical energy induced in the tower during storms may have affected the station's electrical systems in the past. For one thing, the tower and fire station were not connected and therefore existed at different ground potentials.

Lightning energy emanating from the tower could certainly be inducing damage to equipment or driven through the earth to the station by that potential difference.

"The lightning protection system we installed on Fire Station No. 1 was a typical system meeting lightning protection standards," clarifies Bret Peifer, President and Owner of Mr. Lightning. "The process to design the building lightning protection system was straightforward, but the 200-ft-tall TV transmission tower was a different story. We decided to install a shield line that connected the tower to the fire station's lightning protection system. We bonded the steel structure of the antenna. The 60-ft-long shield line that we installed helped to intercept any step voltage from continuing into the building when the antenna got struck."

Mr. Lightning's final step was to lay out a 200-ft triangular array of copper cable along the property line between the tower and the station. (Figure 5) Its job was to absorb and dissipate to earth any high energy that might occur from a direct lightning strike to the tower.



Figure 5. The TV and cellular transmission tower, left, is only 90 feet from the Fire Station No. 1 structure, right, and lightning energy from the tower could have passed to the station through the ground before repairs were

undertaken, especially since the two structures were not connected, and were therefore at different ground potentials. Mr. Lightning's solution was to connect the structures' grounding systems with a buried copper cable to avoid potentially hazardous step potentials. In addition, the company installed a 200-ft triangular copper ground grid at the fence line to absorb and dissipate

Upgrades Paid for Themselves

The system installed by Mr. Lightning has worked flawlessly for more than a decade. There has been no more damage to the fire station's electrical systems and, more importantly, no communications outages. The community is better protected as a result.

CFPD was so pleased with the results at Fire Station No. 1 that it underwrote the installation of similar systems at its other firehouses. None of the district's facilities have experienced any lightning-related electrical problems since.

As for dollar savings, the cost of the new lightning protection systems was certainly reasonable. At Fire Station No. 1, where the system included connection to the 200-ft tower, the total cost of the installation did not exceed \$12,000 or just a few thousand dollars more than the cost to repair the station's lightning damage in an average year. The certified lightning protection system actually paid for itself in less than two thunderstorm seasons. And, every subsequent year without damage at Fire Station No. 1 and CFPD's other stations represents an annual savings of thousands of dollars in avoided repair costs, not to mention the improved reliability the entire system has enjoyed for years. Small wonder that Chief Markham is pleased with the decision to install a robust, 100%-copper, lightning protection system designed and installed to NFPA, UL and LPI standards.

The Principals



David Markham is the Cunningham Division Chief of Operations and directed the installation of a certified lightning protection system at the district's Fire Station No. 1. He can be reached at (303) 755-9202.



Bret Peifer is president and owner of Mr. Lightning, Colorado Springs, CO. A lifetime veteran of the lightning protection industry, Mr. Peifer has worked for Mr. Lightning since he was twelve years of age. He has his Master Installer/Designer Certificate from the Lightning Protection Institute. He can be reached at info@mrlighting.com

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