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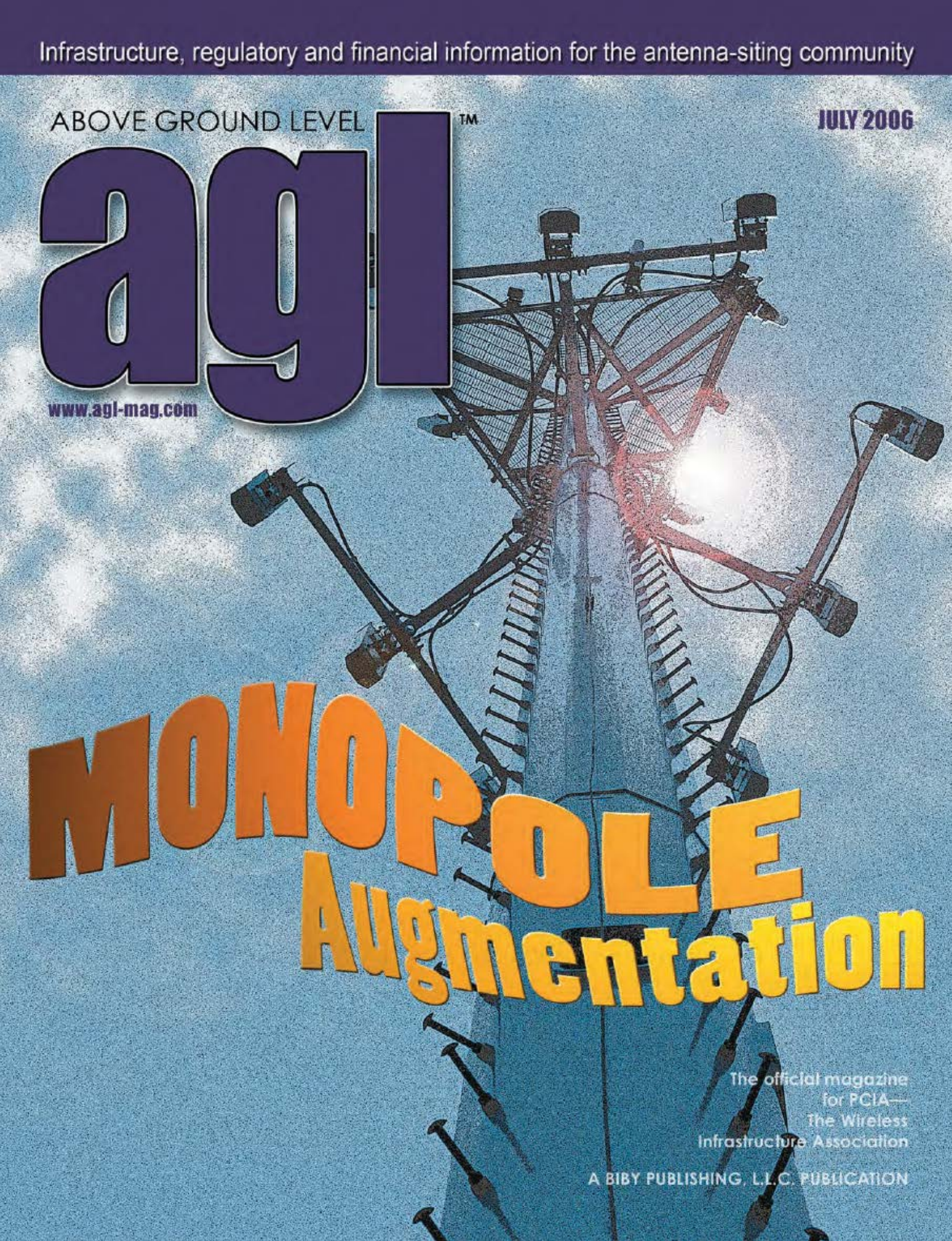

MONOPOLE Augmentation

The official magazine for PCIA—The Wireless Infrastructure Association

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Features

Dave Hawkins (left), co-author of this issue's monopole base plate article (page 30), is Monopole Department manager at Paul J. Ford and Company, Columbus, OH, and also chairs the monopole subcommittee of the TIA TR14.7 Structural Committee. Ford and Company has designed and analyzed thousands of towers and monopoles throughout the United States. A registered professional engineer in 11 states, Dave has over 21 years experience in structural engineering. His co-author, **Brian Reese** (right), is vice president of Operations at Boulder, CO-based AeroSolutions, which specializes in optimizing tower infrastructure and design-build services. Brian also serves as vice-chairman and secretary of the TR14.7 committee. A registered professional engineer, he has worked with engineering and tower infrastructure for 15 years.

PCIA Manager of Industry Affairs and AGL Editorial Advisry Board member **Anne M. Perkins** throws a little light on problems that arise when local governments get involved with—light (page 12). Before joining PCIA, Anne was regulatory affairs director at the Satellite Broadcasting and Communications Association. She also understands how the FCC works, having served as a special assistant to FCC Commissioner Jonathan S. Adelstein. At PCIA Perkins builds and maintains industry relationships with partner and government agency staff, interacts with the FCC, FAA, state and local governments and other federal agencies. She earned a JD from the Columbus School of Law at Catholic University in Washington and has a BA in Government and Philosophy from the College of William and Mary in Williamsburg, VA. She is a member of the Federal Communications Bar Association and the Maryland Bar.

Providers of goods and services for telecommunications and wireless infrastructure face challenges to protect the intellectual property associated with their businesses, including patents, trademarks and trade dress, copyrights and trade secrets. Attorneys **John Bradshaw** and **Delaney DiStefano** begin mapping out this ground this issue with a discussion of trademarks (page 28). **Bradshaw** is a patent and trademark attorney with Woodard Emhardt Moriarty McNett & Henry, Indianapolis. He received a BS in chemical engineering in 1994 from the University of Notre Dame and an MS in chemical engineering in 1996 from the University of Florida. John received his JD, summa cum laude, in 1999 from the Indiana University School of Law where he was also editor for the Indiana Law Review. **DiStefano** is a principal of Higgs Law Group, Rockville, MD. She received her B.A. from St. Lawrence University in Canton, NY and her JD from The George Washington University School of Law in Washington. Delaney has extensive experience in formal complaint proceedings before the FCC representing both complaintants and defendants. She has prepared contracts for such varied purposes as telecommunications tower and rooftop leases, radio system operating agreements, reseller agreements and ITFS build-out agreements. Delaney is a member of the New York State Bar and District of Columbia Bar. She is also a member of the Federal Communications Bar Association and the Radio Club of America.

Successful approaches to overcoming obstacles to siting are outlined this issue (page 24) by attorney **Robert D. Gaudioso,** a partner since 2000 with the New York-based firm of Snyder & Snyder, which he joined in 1994. Rob provides tower-siting guidance on a national level. He is also chairman of Snyder & Snyder's telecommunications land use practice. Rob graduated summa cum laude from Stony Brook University in 1990 (BA, Anthropology) and cum laude from Pace University School Law School (JD, 1993). He also has a Masters of Laws in Environmental Law from Pace University School of Law (1994). Rob is admitted to practice in New York and the U.S. District Court for the Southern District of New York.

PROTECT INVEST

WHAT **EVERY** TOWER OWNER SHOULD KNOW ABOUT UPGRADING A MONOPOLE'S **MOST IMPORTANT CONNECTION**.

BY BRIAN R. REESE, P.E., AND DAVID W. HAWKINS, P.E.

Monopoles are a popular form of antenna support. The reinforcement of existing monopole structures has allowed the industry to increase load-carrying capacity, thereby realizing more revenue per structure by adding carriers. Often in the upgrading of a pole, the base of the pole needs to be strengthened because this is the area of a cantilever structure where the stress is relatively higher than on other parts of the pole. All of the load from the pole above accumulates at the base and must be transferred from the shaft to the base plate into the foundation through the anchor rods. The connection of the base of the pole to the base plate is a critical, non-redundant structural connection. Invest the appropriate attention to this critical connection, and you will prolong the lifespan and ensure the long-term performance of your monopole assets.

The base plate is shop welded to the monopole shaft in the manufacturer's facility. This weld is the *only* connection between the monopole shaft and the base plate.

The elegance of monopoles

Tubular steel poles have been used as a support structure in the electric utility and transportation industries for nearly a half-century. In the telecommunications industry, tubular steel poles, commonly referred to as *monopoles,* have been in service since the growth of the cellular industry in the late 1980s. Fueled by demand for communications services, monopole use by both carriers and tower owners exploded in the late 1990s. While the industry experienced explosive growth, public opposition to the placement of new sites increased.

In response, the industry sought to optimize the load-carrying capacity of existing structures. *Reinforcement* has become a common alternative to installing a new monopole. Upgrade methods include bolt-on structural members, carbon-fiber reinforcement, structural adhesives and welded structural members.

With more than 3,000 monopoles in its portfolio, Crown Castle International (CCI) has taken a proactive approach to managing the upgrade and optimization process of its monopole structures. Jim Kyriacopoulos, CCI's director of engineering, said, "Having investigated most of the common methods for strengthening monopole structures, we prefer bolt-on-type designs for the shaft because we believe they are solid from a performance and reliability perspective, generally the simplest and among the least expensive to install, and nearly maintenance free."

By increasing the structural capacity and use of existing antenna support infrastructure, the industry has slowed the proliferation of "rawland" sites and the deployment of new structures.

Monopole base-plate connection

A critical aspect of monopole reinforcement is the upgrade of the base connection. A monopole base plate connects the structure via anchor bolts to the foundation. The monopole base connection is fabricated by shop welding the base plate to the shaft in the manufacturer's facility. This weld is the only connection between the monopole shaft and the base plate, which makes this type of connection non-redundant. The structural

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Fueled by demand for wireless services, monopole use by carriers and tower owners exploded in the late 1990s.

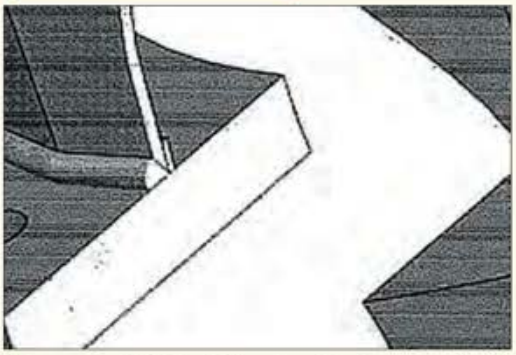

Figure 1. CJP joint cut-out showing butt-welded connection between the base plate and the pole wall.

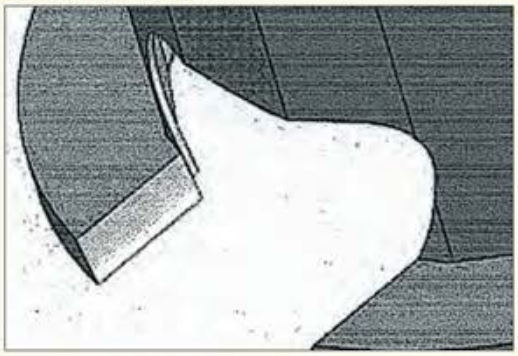

Figure 2. The fillet weld is in the outside-base plate/pole-wall intersection and on the bottom base-plate/pole-wall intersection.

adequacy and integrity of this connection is crucial to the monopole's structural performance. A non-redundant connection means that if a complete failure were to occur at this joint, the result would be almost certain catastrophic collapse of the structure. The connection detail of the monopole shaft to the base plate can vary depending on the type of monopole (multi-sided polygon vs. pipe) or the original manufacturer.

Various base details

■ *Complete joint-penetration groove weld* — The base plate is butted against the bottom of the monopole shaft and consists of 100-percent-complete weld penetration. In other words, the connection zone is all weld material. *(See Figure 1, upper left).*

■ Socket base-plate connection (base plate sleeves over outside of pole wall) with double fillet welds — The fillet weld is in two places: the outside base-plate/pole-wall intersection and on the bottom base-plate/pole-wall intersection. *(See Figure 2, left.)* Although other joints are possible, including the use of stiffeners, the majority of monopoles manufactured generally fall into one of these two categories.

Base-plate reinforcement

When a monopole structure is upgraded for additional load-carrying capacity, a structural analysis is performed to identify where the existing structure may have overstress. The overstress may occur in the monopole shaft, in the base plate or in both. In addition, the anchor rods or foundation may be overloaded. Although one or multiple components may require reinforcement, this article focuses on the base-plate connection, specifically.

As part of a structural analysis, the engineer calculates the loads and stresses in the base plate. Bending stresses that exceed the allowable stress require reinforcement. Typical base-plate reinforcement consists of field-welded, high-strength, steel stiffener plates.

The stiffeners reduce the bending in the base plate to an allowable level. The stiffeners also reduce the relative joint rotation between the existing base plate and the pole shaft. This helps to reduce stress risers and fatigue at the existing joint. Also, the stiffeners provide a stronger load path from the pole shaft to the anchor rods.

Stiffener design and welding

For reliable results, the design of this stiffened-joint reinforcing must be done by qualified and experienced professional engineers. The installation of the stiffener reinforcing must be performed by qualified welding personnel certified to American Welding Society criteria.

The general design philosophy for the stiffeners is to provide a positive load path with ductile transfer of the forces from the shaft into the base plate and the anchor rods. This is achieved by sizing the stiffener to carry the appropriate calculated forces and to detail it having a fairly large height-to-length ratio, such as 3:1. The tall stiffeners, which are tapered, help to reduce the concentration of stress in the pole shaft at the top of the stiffener.

The field welds between the new stiffeners and the existing shaft and base plate are designed to carry the calculated forces in the stiffener. Generally, the vertical welds between the stiffener and shaft are *fillet welds*. Depending on the dimensions and the magnitude of the loads, the horizontal welds between the bottom of the stiffeners and the top of the base plate might be fillet welds or *partial-* or *complete-penetration* welds.

The new vertical and horizontal field welds should not intersect the existing base-plate weld. The new welds should stop short of the existing weld so that any undetected flaws or cracks in the existing weld do not *migrate,* or flow, into the new welds. Of course, after the new field welds have been completed, they too must be inspected and approved by an American Welding Society-certified weld inspector.

"We recognized, early on, the significance of base-plate connections and have developed programs to ensure structural integrity," Kyriacopoulos said. "We regularly clean, inspect and photograph the baseplates as part of our field maintenance and to keep a running log for reference.

Base plate with stiffeners.

A team of engineers has worked to standardize base-plate analysis and stiffener designs to drive for consistency. Part of the process to reinforce a pole shaft includes the existing weld connections to be critically inspected with non-destructive test methods, since even greater load will be carried through the connection. Finally, new welds must be accepted by a certified weld inspector (CWI) before the engineer of record completes the post modification report. This effort is an example of our systematic, long-term approach to the structural process and illustrates how Crown Castle is able to provide safe, reliable structures to the telecom market."

Base-plate connection cracks

It is imperative to investigate the integrity of the base-plate weld connection when upgrading a monopole structure.

Figures 4a and 4b. A magnetic particle test reveals an exposed crack.

An ASNT inspector ultrasonically tests a base-weld connection. In the last frame, the defect is revealed at the toe of the weld on the pole bend line.

Existing cracks in this connection must be properly identified and repaired during the reinforcement process. A crack in a weld or base metal is a fracture or break in a material that was previously *solid* and then *separated* because of stress. Cracking occurs in a weld and base metal when the localized stresses at the connection exceed the ultimate strength of the steel material. Left in place without repair, existing cracks will enlarge and propagate over time with loading cycles and are detrimental to structural adequacy. The *AWS Structural Welding Code D1.1 (Table 6.1, Part 1)* does not allow a crack to remain after inspection. The crack *must* be properly repaired.

Base-plate connection crack repair

The *AWS Welding Code (Section 5.26)* addresses repair of welded connections, and Section 8 addresses the strengthening and repairing of existing structures. To ensure the long-term, reliable performance of a monopole structure, the diagnosis and repair of cracks at monopole bases should be accomplished as follows:

1. *Identify base connection detail*:
   a) complete-penetration joint.
   b) socket base-plate connection.
2. *Visual inspection* — Visual identification, by a certified welding inspector or an inspector with AWS Code qualifications, of joint deviations from *American Welding Society D1.1 Table 6.1* criteria. However, a *visual* inspection may only detect aggravated conditions with *pronounced* defects. This is not sufficient for conclusive results.
3. *NDT Magnetic Particle Testing* — Conducted by an inspector with American Society for Non-destructive Testing (ASNT) Level II certification, this nondestructive test assesses surface cracks in joints that are not 100 percent complete-penetration joints (i.e., socket base-plate connections). Defects hold magnetic particle material applied during the test, identifying the presence of a crack. *(See Figures 4a and 4b above.)*
4. *NDT Ultrasonic Testing* — Also conducted by an ASNT Level II inspector, this method is used for testing of joints that are 100 percent complete-penetration joints. The test uses ultrasonic waves that are interrupted by any inconsistencies (cracks) in the joint.
5. *Assessment of defects* — Assess the extent of cracks, their length and position. Cracks typically require installation of welded base-plate stiffeners designed on a case-by-case basis.
6. *Defect repair* — The last stage is to repair the weld, or to reinforce the monopole base connection, or both. The scope of the strengthening stage depends on the results of the diagnosis and structural analysis. Significant cracks may require drilled terminations. In addition, stiffeners may be part of the recommended repair.

The monopole base-plate connection is critical. It is imperative that it is inspected by qualified, experienced personnel with CWI and ASNT credentials.

In a comprehensive monopole upgrade, the existing monopole base-plate connection must also be inspected. Even if the base does not need strengthening, it is still important to perform regular inspections of the base-weld connection.

The proper weld inspection, diagnosis, design and reinforcement of monopole base-plate connections is critical to the proper performance and maintenance of antenna structure assets. Using experienced and qualified personnel for these services is essential.

Proper management of your monopole assets will ensure the revenue stream of your investment.

Properly inspected, designed and installed reinforcement for additional load-carrying capacity will also avail you of reliable infrastructure to support revenue growth. **agl**

Installation, by a certified welder, of reinforcing base-plate stiffeners to strengthen the base plate.

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