Osmose®

OSMO-C-TRUSS®

55 Years OF RELIABLE RESTORATION

2020 marks the 55th anniversary of the Osmo-C-Truss wood pole restoration system. Installations of the C-Truss® and C2-Truss™ have restored over 1.5 million poles nationwide. These restorations also represent over $3 billion in savings for utility companies when compared to pole replacement costs. Furthermore, the wood pole life extension provided by these systems can be equivalent to the expected life of a pole replacement.

This paper shows a brief history of the C-Truss steel restoration method and includes data on the re-inspection of over 117,000 restored poles that validates successful life extension of over 40 years. Life extension of a utility asset qualifies for capital treatment and details of capital budget optimization are also explained in this document.

Wood Pole Restoration

The first wood utility poles were installed over 100 years ago and today an estimated 150 million wood poles provide the support system for much of the electric grid. As poles age while in service, the original preservative treatment may no longer be effective at preventing decay in the groundline zone. The most decay prone section of the pole is from groundline to 18 inches below ground.

Inspection of the groundline zone, especially when excavation is included, monitors the condition of a pole and is recommended and sometimes required on a cyclical basis. The excavation also provides the means to apply supplemental preservative treatment; a booster shot to the original treatment that helps prevent decay and extend the life of a pole.

Poles identified with a remaining bending strength at the groundline that is below the requirements of the National Electrical Safety Code (NESC) are often referred to as "rejected" poles or "rejects." The code requires these poles to be restored or replaced.

Pole restoration with the Osmo-C-Truss system has provided utility companies with a cost-saving option to pole replacement for 55 years. The steel truss is positioned against the pole and is driven into the ground to a depth well below the groundline decay zone. This forms a union with the sound portion of the pole below the decay zone, and the above ground portion of the truss is banded to sound wood above. The steel truss bridges across the decay zone and restores the bending capacity so the pole can remain safely in service.

The flexibility of the installation method makes it possible to restore poles that are installed in rear-lots and in concrete along with poles having various attachments and difficult access.

Due to the historical data validating significant life extension, the cost of the C-Truss system can be capitalized and used to help optimize capital budgets.

TIMELINE

Reliable innovation that spans over five decades.

1965
Birth of the original c-shaped truss

1970s
Introduction of high strength steel-plate material

1980s
- Optimized for NESC code
- Increased size range

1990s
Capacity upgrade solutions developed

2000s
- C2-Truss introduced
- Higher strength, lighter weight
- Improved efficiency

2010s
Additional sizes added for telco market

2020s
- Continued truss innovation
- Enhanced life extention analytics

The Origin of Pole Restoration

The first C-Truss can be traced back to 1965, with the use of a C-shaped channel that was driven alongside a pole and secured with steel banding. The first C-Truss systems incorporated lengths of pipes that were not acceptable for oil pipeline applications. These "repurposed" oil pipes were cut in half longitudinally, thus creating a "C" shaped cross-section. In the early years of use, it was perceived by utility companies as a temporary solution that may only extend the useful life of a pole for five to 10 years; however, poles restored during this time can still be found in service today providing evidence of a much longer life extension.

In the 1960's, utility companies often conducted their own tests of new products that were brought to market. **Figure 1** is an example of full-scale testing of the early C-Truss system conducted at a Midwestern utility company in 1966.

Figure 1 1966 In-situ Load Testing of C-Truss

A Brief History of Continued Development

The very first oil pipe restorations did not have any form of corrosion protection. Hot-dip galvanizing was soon added to the manufacturing process. All Osmose trusses are galvanized according to the ASTM A123 standard.

Osmose moved away from repurposed oil pipes and exclusively to formed trusses out of steel plate. Further enhancements were made by incorporating high strength low alloy steel plate. This provided more bending strength without an increase in weight. At that time, all trusses were standardized using 60,000 yield strength steel.

In the mid 1980's, the C-Truss had its first major design overhaul. The general C-shape was improved by creating truss sizes that efficiently coincided with NESC code requirements. Higher strength steel (80,000 psi) was incorporated to achieve greater bending strength in lighter weight trusses, further optimizing the design.

Optimized C-Truss Installed

As the capabilities of the steel truss improved, the banding system, used to secure the truss to the pole, was also enhanced. Osmose began manufacturing industry-leading tensile strength banding (138,000 psi) and protected it with hot-dip galvanizing, which provides three times the amount of corrosion protection over electroplating.

The redesigned C-Truss system was thoroughly tested and evaluated throughout the latter 1980's and early 1990's. Full-scale load tests were independently witnessed to validate results, and several utility companies conducted their own on-site validations across the country.

In the late 1990's, higher strength steel (100,000 psi) became more readily available and cost effective. Osmose developed a new truss that could utilize this higher strength, lighter weight material. Higher yield strength steel trusses behave differently than trusses made with lower yield strength and should not be directly substituted without considering the impact on overall performance. For this reason, a new cross-sectional shape was developed specially for the higher yield steel to have an improved margin of performance over the "C" shape trusses.

After extensive research, FEA modeling (**Figure 2**), design development, and testing, the Osmo-C2-Truss® was introduced in the early 2000's.

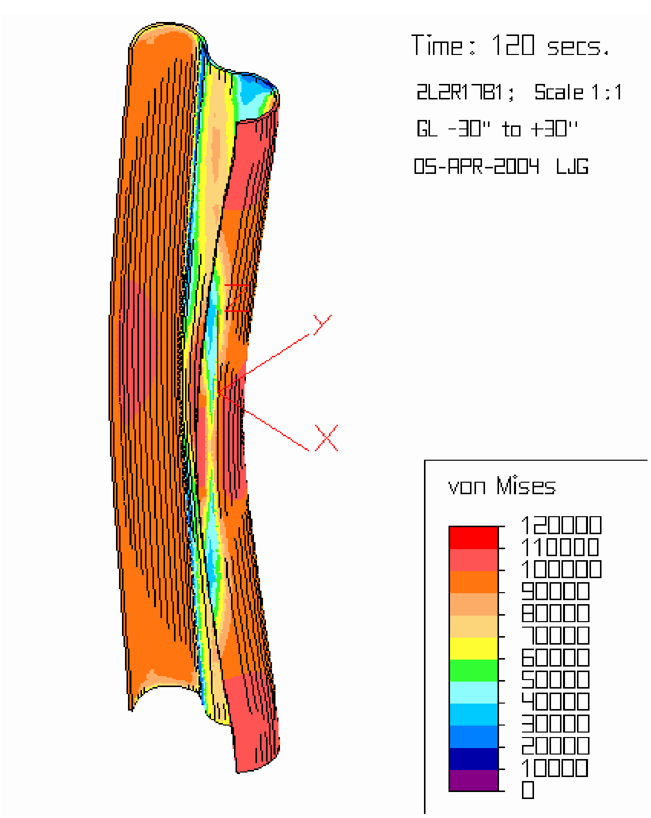


Figure 2 Model of Stress Under Load

The patent-protected C2-Truss™ provides a lighter, stronger, and lower cost solution for restoration, giving an even greater incentive for the pole owner to restore rather than replace their rejected wood poles.

Ensuring Optimal Life Extension

In order to achieve long life of the restoration system, the truss itself must adequately resist corrosion, and the wood pole must be treated to arrest further decay.

C-Truss and C2-Truss products are hot-dip galvanized to strict standards under the ASTM A123 specification, and banding strips are hot-dip galvanized in accordance with ASTM A653. Products galvanized to these standards have been shown to withstand outdoor environments for well over 50 years.

Every truss, when installed, is paired with highly effective remedial treatments applied to the pole to arrest further pole decay. To gain the greatest life extension, pole owners should continue to include trussed poles on the same inspection and treatment cycle as the rest of the pole plant. This will provide a booster shot of preservative treatment to inhibit decay.

Patented C2-Truss Installed

Years Since Restoration	Poles Re-Inspected	Poles Still Serviceable	Serviceable Rate
10-19	65,074	61,500	95%
20-29	36,330	33,767	93%
30-39	15,322	14,122	92%
40+	973	876	90%
10+	**117,699**	**110,265**	**94%**

Table 1 Restoration Decade Age Groups and Serviceability Rates

Observed Trussed Pole Life Extension

Osmo-C and C2 Trussing Systems are robust. With over 1.5 million installations nationwide, Osmose is not aware of any steel trusses that have failed (broken) while in service when resisting the bending loads they are designed to withstand. Osmose steel trussing systems have reliably withstood day-to-day weather loads and extreme weather events. If fact, Osmose trusses are so robust that utilities have reused trusses removed from years of successful service to properly restore another weakened pole, which saves restoration material cost.

Osmose highly recommends inspecting and remedially treating restored poles on an appropriate cycle with the rest of the wood pole plant. For the truss to reliably remain in service, minimum criteria of the wood pole condition must be met. Those criteria, shown in **Figure 3**, include sound wood shell requirements in the trussed zone as well as a serviceable condition of the wood above the trussed zone (including the pole top). Osmose technicians are trained to evaluate these criteria to determine if the wood pole is still in a condition to remain properly restored with a steel truss. It is important to the longevity of a trussed pole system to continue to remedially treat the trussed zone to arrest further decay. Trussed poles that do not meet the minimum requirements for restoration are deemed not serviceable and are recommended for safe, scheduled replacement. The truss system itself is also visually inspected for any damage that would be recommended for follow-up maintenance or replacement. Osmose has compiled empirical evidence validating that the C-Truss and C2-Truss Systems add decades of service life to wood poles originally rejected due to ground line decay or damage. **Table 1** represents an analysis of routine inspection data dating back to 2008 through 2019 on over 117,000 previously trussed poles from utilities with a long history of restoration and pole inspection and treatment with Osmose. It clearly illustrates the significant life extension an Osmose truss system can provide. Each decade age band of a truss in service shows a very high rate of satisfying all minimum wood condition criteria described in **Figure 3**, so the pole may remain in service until the next inspection cycle.

As awareness and popularity of the C-Truss grew over the past 55 years, so too have the number of steel truss installations. At its inception, steel trusses were installed for a smaller number of customers, which helps to explain the smaller population of older steel trusses in **Table 1**. Although the population is smaller, high serviceability rates are maintained.

CRITERIA FOR SERVICABLE RESTORED POLES

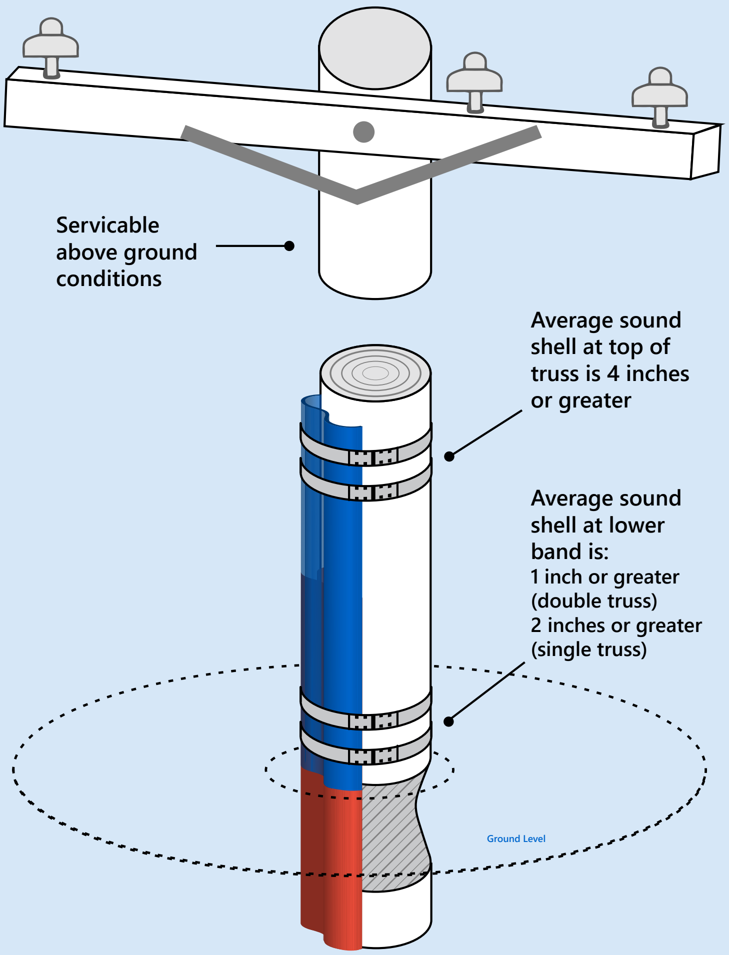


Figure 3 Minimum Wood Pole Condition Requirements for Steel Truss Restoration

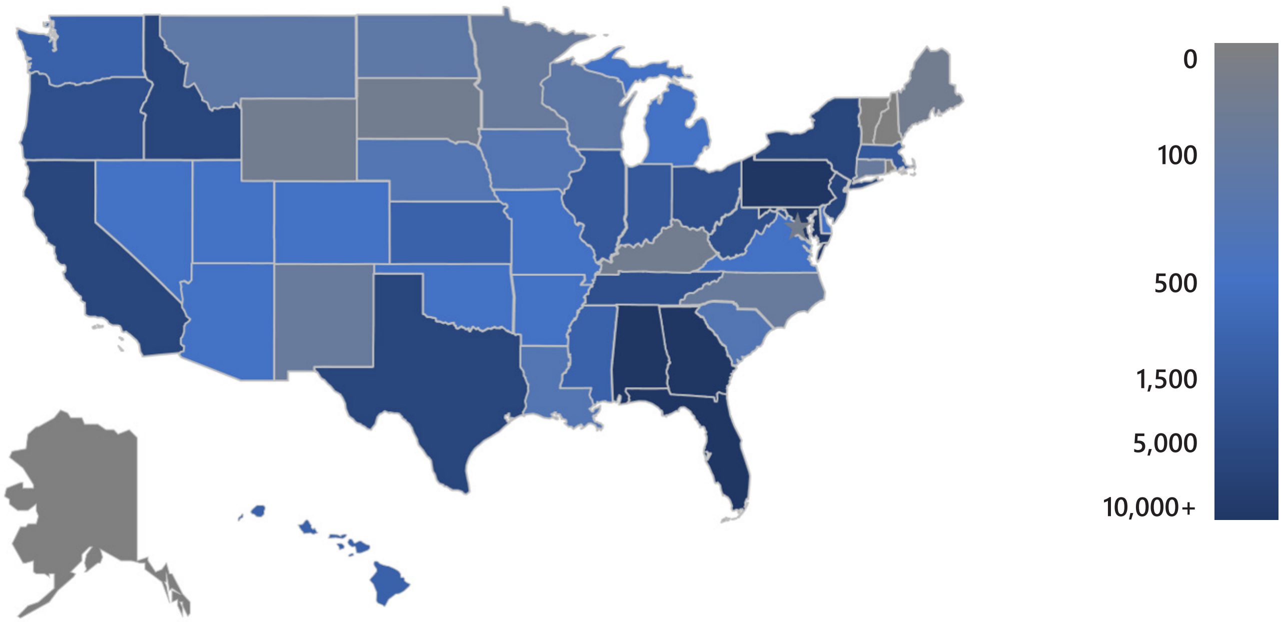


Figure 4 Heat Map of Restored Poles in the Serviceable Study Data Set

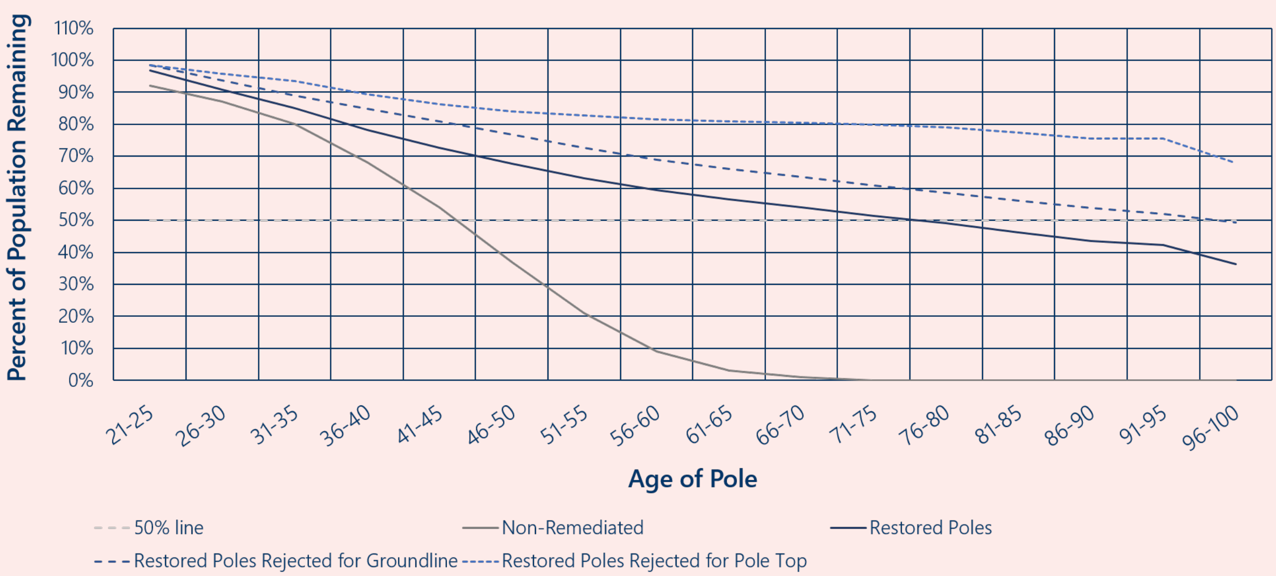
The poles represented in **Table 1** are shown geographically in **Figure 4**. As shown on the map, many of the poles are in higher risk decay zones, which makes the longevity of the Osmose Trussing Systems paired with effective remedial treatments even more impressive.

A wood pole survivor curve measures the proportion of poles still in service as the poles age. When a survivor curve reaches a proportion of 50%, it is interpreted as the average age a pole survives. **Figure 5** shows survivor curves for several different categories. The first category of non-remediated poles is based on independent analysis of a large sample set of over 450,000 inspections of poles that were never remedially treated or restored. The data used to graph the various restored poles survivor curves is showing the total age of poles with trusses installed and is congruent with the data shown in Table 1. From the data presented, a pole plant which goes without ground line remedial treatment may see an average service life of 41-45 years. By utilizing a best-in-class inspection and treatment program and full use of pole restoration a pole plants average life expectancy could be pushed out to 80+ years.

Furthermore, the data based on previously trussed poles empirically shows that for trussed wood poles only recommended for replacement due to trussed zone decay conditions (restored poles rejected for groundline), an average service life has the possibility of being pushed out to 100 years. This incredible life extension may be attainable by protecting pole tops from degradation with Pole Toppers® in conjunction with an Osmose life extension program.

Overall, the data supports Osmose steel restoration as a positive, long term solution which provides comparable life extension to that of a new pole.

Figure 5 Survivor Curves by Pole Age for Non-Restored Poles and Restored Poles



The Case for Capitalization of Pole Reinforcement

As previously outlined and qualified through empirical data analysis, steel truss reinforcement extends the useful life of a wood pole well beyond when it is deemed a reject. As such, it represents an addition or betterment to the pole plant and can be classified as a capital expense.

This concept is clearly supported in the Federal Energy Regulatory Commission's (FERC) 2008 ruling on Novinium, Inc.'s request for capital treatment of the costs involved in installing injection rehabilitation products for URD cable. The approval from FERC notes "a company may capitalize the cost of installing injection rehabilitation products provided that the product is used by the company to extend the useful life of its segments of URD cables beyond their original estimated useful lives."

In a subsequent 2011 ruling on a petition filed by Waverly Light and Power, the commission allowed utilities to capitalize all costs incurred to retro-fill a substation transformer with a new dielectric coolant. FERC affirmed the fluid qualified "as a minor item of property that did not previously exist provided that a substantial addition results from its use."

In addition, The Rural Utilities Service (RUS), the government agency that provides capital and leadership to cooperative utilities across the country recently determined that pole restoration is eligible for RUS financing in the RUS Coding Guide as RUS Code 618 – Pole Restoration, and eligible for capitalization under USOA, Account 364-Poles, Towers and Fixtures.

Osmose trusses are specifically engineered and sized through detailed engineering analysis to restore a pole's strength. Trussing achieves increased service life, capacity, and durability for older, in-service wood poles. It clearly meets the criteria established to be classified as a capital expense.

Capital Budget Optimization

While the availability of capital is typically less constrained than O & M, operating managers must still ensure budgets are spent in a way that maximizes the overall value and benefit to the organization. In most utility companies the total capital available is less than what's needed to fund all the potential projects that have a positive return to the enterprise. A process of internal "capital rationing" is generally used to balance these local work projects with the other needs of the organization. With this in mind, it is compelling to restore a pole for a fraction of the cost of replacing it in order to make capital available for additional projects.

In evaluating restoration versus replacement from a pure cost-savings perspective, a utility would ideally reinforce the maximum number of eligible poles to minimize the remaining population requiring replacement. Steel trusses are used unless there are mitigating engineering reasons, construction standard changes, new clearance requirements, or other factors that indicate pole replacement is the more desirable approach. This strategy can allow the utility to fully address their reject pole backlog within the allowable capital budget spend.

The decision to restore rejected poles may also be evaluated outside of a purely financial assessment. Pole replacement can be a lengthy and complicated process. Replacement prioritization, potential customer downtime, permitting, coordination with pole attachers, and back-office preparation all contribute to an overall project timeline that can take many months or even years to fully complete. With so many departments involved and so many steps taken during a pole replacement process, it is very common for a backlog to develop and increase to unsustainable levels. A pole restoration program can be implemented quickly and the backlog of rejected poles can be addressed in a timely manner, thus reducing the rejected pole backlog and the pole owner's overall risk and liability. Program Managers concerned about any long-term rate base impacts of the restore versus replace decision can be assured there are always a myriad of other project opportunities within the company. Funding additional projects with the money saved through restoration ensures a robust annual capital spend and eliminates the declining rate base concern that is often a decision-making factor.

The Next 50 Years of Restoration

Over the first 55 years, Osmose has worked to ensure that customers received industry leading reliable restoration products and services through substantial product improvements, quality workmanship, and best-in-class safety practices.

Re-inspection data supports that Osmose C-Trusses and C2-Trusses are long term solutions, and long-time customers can attest to the substantial life extension steel trusses have given to their pole plant as well as numerous other benefits. These benefits include safely and effectively restoring wood poles to NESC code mandated strength for a fraction of the cost of pole replacement, without service interruptions, and reducing overall risk and liability to the pole owner.

Osmose engineers continue to evaluate designs, materials, and processes as technology evolves to provide the best pole restoration solutions for their customers. With 55 years of restoration experience, work will continue toward providing new innovations that are reliable and cost-effective restoration solutions for pole owners.