Alternatives to Wood Poles and Crossarms

H. Robert Lash, Chief, and Norris Nicholson, Electrical Engineer, Transmission Branch, RUS

ALTERNATIVES TO WOOD POLES AND CROSSARMS

For over twenty years the utility industry has been using tubular steel poles for transmission structures. For the last three to four years, light duty tubular steel poles began being used on distribution lines. This usage may be partly due to the gradual increase in the cost of wood poles caused by harvesting restrictions, supply and demand pressures and increases in preservative costs. At the same time, technology has reduced the manufacturing costs for light duty steel poles. Because steel poles are lighter in weight than comparable wood poles, use of steel poles for distribution may have also increased because they are perceived to be easier and faster to install. These factors have led light duty steel poles to be competitive in cost compared to wood poles for distribution lines when looking at the lifetime line cost.

The road to Steel Distribution Poles

For over sixty years wood poles construction has been the standard for distribution lines at RUS (formerly REA). The use of steel poles to any extent in REA transmission lines began in the early 70's. These poles were designed using loading trees developed by the cooperatives or the consulting engineer. The steel pole manufacturers realized that offering the industry a standard pre-engineered pole would reduce the manufacturing costs and would offer other benefits. In the mid 80's, the manufacturers pre-engineered their poles into standard classes and called them 'Wood Equivalent poles'. The concept was to offer standard class poles that could be interchangeable with comparable wood poles used in transmission lines. Since most transmission lines are built to meet NESC Grade B construction, the manufacturers developed their standard class (or pre-engineered) steel poles based on the ratio of Grade B overload capacity factors (OLF). Thus, using the ratio of overload factors for steel and wood for Grade B construction (2.5/4.0) and using the load two feet from the top for wood poles (ANSI O5.1), the manufactures developed their 'Wood Equivalent' standard class poles and published them in their catalogs.

'Wood equivalency' and Grade C Construction

The concern of RUS is the topic of “Wood Pole Equivalency”. Each material has it’s own properties, so it’s difficult to say that one material is equivalent to another. The benefit of wood is its high strength to weight ratio, great insulating properties, ease of field drilling, and low cost. Steel poles can be manufactured to the required strength by varying the material thickness or the pole diameter. There is no need to be concerned about knots or sweep with steel poles.

RUS is concerned with making a direct substitution of wood poles with steel poles of the same designation for distribution lines. The problem lies in the differences in the OLF. The scariest story that has been relayed to RUS involved a purchaser that used the following logic to determine what OLF to use on the steel pole design. According to the NESC for distribution lines (grade C construction), the OLF for wood poles is 2.0 at a crossing or 1.75 not at a crossing. If there is deterioration due to any cause such as decay or mechanical damage, the pole is allowed to lose strength until the OLF reaches1.33. This is a decrease of 1/3 its strength. Since steel is not expected to lose any strength over time, the purchaser felt that it was safe to buy a pole with an OLF of 1.33. This is 40 percent below the required OLF required by the NESC for steel poles for new construction.

According to Table 253-2 of the NESC, for Grade C wood structures the “when installed” OLF is 1.75 for transverse loads. Table 253-1 shows that the OLF of Grade C steel poles is 2.2. This is where the problem arises. The overload factor for steel is higher than the factor for wood for Grade C construction.

As noted earlier, most manufacturers standardize on steel poles such that the poles have a “wood pole equivalency” basis using Grade B requirements in the NESC. Table 1 below summarizes the loads used to design poles:

Table 1
<u>Wood Equivalent Steel Poles</u>
Grade B Construction

Pole Class	Wood Pole Tip Loads (lbs.)	Steel Pole 'Equivalent' Load (lbs.)
1	4500	2925
2	3700	2405
3	3000	1950
4	2400	1560
5	1900	1235
6	1500	975

Table 253-1 of the NESC requires that steel pole designs use an OLF of 2.5 for transverse wind load for Grade B construction. For Grade B construction of wood pole the OLF of 4.0 is required on transverse loads. The required steel pole strength to be equivalent to wood pole moment carrying capacity for Grade B is a ratio of 2.5/4.0 or 62.5%.

Table 2 below equates the "wood equivalent" steel pole for Grade C construction. The corresponding tip load for a class 4-40 (class 4, 40 foot) steel pole for Grade C is 2565 lbs. From Table 1, the corresponding tip load for a 4-40 for Grade B construction is 1560 lbs. When purchasing steel poles, the grade of construction is the major determining factor.

Table 2
Wood Equivalent Steel Poles
Grade C Construction

Pole Class	Wood Pole Tip Loads (lbs.)	Steel Pole 'Equivalent' Load (lbs.)
1	4500	4810
2	3700	3960
3	3000	3210
4	2400	2565
5	1900	2030
6	1500	1605

An example will be used to demonstrate the confusion when using standard class steel poles.

Example

A cooperative wants to build a distribution line meeting Grade C construction. The design calls for 40-4 wood poles but the decision is made that one section will use steel distribution poles. The transverse working load (load without overload factors) is 2400/2.0= 1200 lbs. two feet from the top of the wood pole. The common practice is to substitute a standard class pole, designated as a 40-4, for the wood pole. From Table 1, the ultimate load for the equivalent steel pole for Grade B would be 1560 lbs.

But, this is where the problem occurs. The “ultimate” load to which the steel pole needs to be designed, should be 1200 lbs. (working load) x 2.2 (steel OLF)=2640 lbs.

In the Table 1 the 2640 lbs. ultimate load corresponds to a Class 1 steel pole.

If a 40-4 steel pole with a tip load of 1500 lbs. were selected, it would not meet the NESC strength requirement

Electrical Effects

RUS strongly advocates a minimum lightning impulse withstand strength (often incorrectly and simply referred to as a BIL level) of 300kV for distribution pole top assemblies. A minimum of 300 kV withstand needs to be maintained at dead-end assemblies. Withstand strengths of less than 300 kV will usually facilitate flashovers of lightning strikes to or in the proximity of distribution lines. A recloser operation, which will cause lights to flicker, is usually required to clear the resulting arc. Thus, a minimum of 300 kV withstand is required to maintain a reasonable quality of service. Standard RUS pole top assemblies, with wood poles, have a minimum withstand strength of 350 to 499 kV. If the steel pole design has a withstand strength of less than 300kV, cooperatives should consider what additional measures, such as the installation of surge arresters or the use of fiberglass pole top pins to increase the withstand. The quality of service may be negatively impacted if the withstand of less than 300 kV is maintained.

A steel pole may be used as a grounding conductor if the pole meets the sufficient conductivity and low impedance requirements of the NESC and RUS specifications. However, a directly embedded steel pole is not recognized in the NESC as a grounding electrode. Thus NESC and RUS requires that a separate driven electrode be used for all equipment, surge arresters and other required system grounds, including grounding the poles themselves, if needed.

Cooperatives should use stainless steel or galvanized steel ground rods and non-copper ground wire in the soil on steel poles lines to mitigate the corrosive effects of buried dissimilar metal in close proximity.

Raptor Protection

RUS advocates that distribution lines be designed and constructed in a way that will minimize the electrocution of raptors. Distribution construction with steel poles needs additional consideration because of the short distances between the bare energized phase conductors and the grounded steel pole.

On single-phase lines, the installation of fiberglass-reinforced plastic pole-top pins will minimize the number of electrocutions of small raptors. On three-phase lines, some raptor protection can be achieved in an economical manner by installing fiberglass-reinforced pole-top pins and perch guards on the crossarms. Good raptor protection can be achieved on both single-phase and three-phase structures by:

- Installing fiberglass-reinforced plastic pole-top pins;

- Using non-metallic crossarms and covering the pole, from the neutral up to and including the top of the pole, with an insulating coating that has a dielectric strength of at least 15,000 volts; and

- Using at least a 36-inch fiberglass-reinforced plastic guy strain insulators and extension links for all connections to the pole above the neutral position.

RUS is familiar enough with the use of light duty steel poles that their case-by-case approval has been streamlined. RUS needs the information requested below to determine if the steel pole application would result in safe reliable construction and meet all of RUS' requirements:

1. Indicate the maximum number of steel poles to be used.
2. Indicate the name of the steel pole supplier.
3. Define the project or locations where steel poles will be installed.
4. Indicate reason for using steel poles.
5. Indicate that only RUS accepted materials are to be used.
6. Indicate that RUS standard construction is to be used.
7. If less than 300 kV withstand strength, briefly describe assemblies and materials to be used and anticipated impact on reliability and materials.
8. Describe raptor protection measures.
9. Indicate that the determination of the class of steel pole is based on the proper engineering calculations.

Alternatives to Wood Crossarms

Along with the use of steel to construct light duty poles, there has been considerable interest in alternative materials for crossarms. From the early beginnings of the power industry wood has been the standard in overhead construction due to its strength, durability, and electrical properties. The relative abundance of wood made it an ideal raw material also. As environmental restrictions become more stringent, along with economic pressures, the need for an alternative material to wood has grown. Some factors include the rising cost of production and environmental regulation of wood preservatives. Recently the crossarm has been the subject of study in the rural as well as urban utility companies. Co-ops are looking for products with an increased useful life, as well as lower maintenance cost. Alternatives, such as fiber composites and recycled materials such as rubber, are being investigated as possible foundations for new crossarms. These materials are expected to uphold the same standards or exceed those of existing wood crossarms. The utility industry has taken a special interest lately in fiberglass as an alternative material for wood crossarms.

Fiber Composites

Composites consist of thermoset resin and fiber reinforcement. The resin, in its liquid form, is combined with the fiber and then cured into a solid laminate. There are numerous composite resins and reinforcements, each with a unique property to impart to the finished product. However, most composite fabrication utilizes one of at least six major family groups of resin systems[1]:

- Polyester
- Vinylester
- Modified acrylic
- Epoxy
- Phenolic
- Urethane

The type of resin system used is selected based on the functionality of the product. Production cost is also a major factor in the system selection. Just as there are numerous composite resins, there are a number of reinforcement

1 Lacovara, B., What Every Engineer Should Know About Composites, Composites Fabricators Association, http://www.cfa-hq.org, 1999.

fibers available. The reinforcement fiber, just as the resin selection, depends on the functionality of the end product. Some reinforcement fibers include:

- Kevlar;
- Carbon;
- Glass.

Glass fiber is the most commonly used of the on the market today. Most manufacturers utilize glass fibers due to its low cost with exceptional strength characteristics. Glass fiber is the optimum choice in crossarm production because the material is easier to work with in the manufacturing process.

RUS Requirements

Electric Staff Division has recently developed an Items Required Sheet for listing fiberglass crossarms in Informational Publication 200-1, RUS List of Materials. In order to gain acceptance there are some basic requirements that must be shared with wood crossarms:

- Meet the same load capacity as the standard wood crossarms (unbraced);
- Meet the same cross section as the wood crossarm;
- Meet the same environmental requirements as the wood crossarm.

These are some basic requirements that RUS feels will provide Co-ops and their customers with quality service comparable to that of wood. RUS also requests that certain design and test requirements be met, all of which are outlined in Items Required in an Application for RUS Acceptance of Fiberglass Crossarms.

Testing

A vertical and longitudinal test should meet or exceed the ultimate moment capacity and deflection characteristics of an equivalent wood crossarm. ANSI 05.3 - 1995 Annex B outlines the standard procedure in this test. A moment of rupture (MOR) equivalent to 7400 psi and a moment of elasticity (MOE) equivalent to 1.8×10^6 psi are thresholds RUS recommends for this test. These guidelines are based on each major axis of and equivalent wood crossarms.

The transverse pin test requires that a load be applied to 1-3/8" thread pin with a 2-1/4" washer mounted on the fiberglass crossarm. This pin is item f in the RUS List of Materials. The crossarm is to be loaded to 1650 lbs. or until the ultimate transverse load is achieved. The fiberglass crossarm must withstand a 750 lb. transverse load without any crushing of the arm.

An electrical test as well as an aging and weathering test should be performed also. For the electrical test, dry flashover between the mounting hole and the farthest end pin hole should be measured. ASTM G53 specifies how the accelerated weathering and ultraviolet tests should be fashioned. At least 2500 hours of ultraviolet aging should be conducted without any deterioration of the arm.

Design

RUS requests a number of design features for fiberglass crossarms that should maintain the standard of wood arms and smooth the transition to fiberglass crossarms. For ease of installation, RUS requests that the attachment method of the crossarm to the pole be consistent or the same as that of the wood arm. It is also requested that the arm be equivalent in size to the standard RUS wood arm along with the ability to be field drilled through the centerline of each major axis.

For safety and durability, crossarms should be designed for a minimum of 30 years exterior exposure and for a minimum crushing load 500 psi under the washer without any permanent deformation or damage.

ITEMS REQUIRED IN AN APPLICATION FOR RUS ACCEPTANCE OF FIBERGLASS CROSSARMS

1. **Test Requirements:**

♦ Vertical and longitudinal crossarms tests - The fiberglass crossarms should meet or exceed ultimate moment capacity and deflection characteristics of equivalent wood arms for of each major axis (wood crossarm based on an MOR of 7400 psi and MOE of $1.8x10^6$ psi) . Test crossarms in accordance with ANSI 05.3 – 1995 Annex B.

♦ Transverse Pin Test

a. Transverse load to be applied to a 1-3/8" thread pin (item f) with a 2 1/4" washer mounted on the fiberglass crossarm.
b. No crushing of the fiberglass member is permitted for a transverse load up to 750 lbs transverse load.
c. Transverse load to be gradually increased to 1650 lbs or ultimate, whichever comes first. Report results.

♦ Longitudinal Pin Test - Apply 700 lbs to a 1 3/8" thread pin (item f) with a 2 1/4" washer in the longitudinal direction.

♦ Electrical Test - Perform a dry flashover test between the crossarm mounting hole and the farthest end pin hole. Report the results.

♦ Weathering and Aging Tests - Crossarms shall be tested for accelerated weathering and ultraviolet aging for 2500 hours without any deterioration in accordance with ASTM G53, *Practice for operating light-and water-exposure apparatus (fluorescence UV - condensation type) for exposure of non-metallic materials;*

2. **Design Requirements:**

♦ Arms shall be equivalent in size to RUS standard size wood arms;
♦ Crossarm must be able to be field drilled through the center line of each major axis;
♦ Attachment method of the crossarm to the pole must be consistent or same as wood the crossarm;
♦ Crossarms shall be designed for a minimum of 30 years of exterior exposure.
♦ Crossarms shall be foam-filled to eliminate water ingress. Filler shall be closed cell and completely fill the crossarm. End caps shall be permanently affixed;
♦ Each crossarm shall be permanently marked with the manufacturer's name or logo and date of manufacture.
♦ Crossarm shall be designed for a minimum crushing load of 500 psi under washer without any permanent deformation or damage.

Refer to "General Requirements in an Application for RUS Acceptance of a Product" for additional information.

RUS Guidelines and Approval for the Use of Distribution Steel Poles

The Rural Utilities Service (RUS) will consider a borrower's written request to use distribution steel poles for site specific projects on a case-by-case trial basis to gain experience. Before granting approval, RUS needs sufficient information to assure that the application of steel poles will result in safe and reliable construction and meet RUS requirements.

Borrowers requesting RUS approval to use distribution steel poles are asked to read the following guidelines and design information and to furnish RUS with the information requested in Part II.

Part I: RUS Guidelines and Design Information for Using Distribution Steel Poles

A: MATERIALS

Except for various miscellaneous material items, RUS regulations require that borrowers use materials that RUS has fully, conditionally or technically accepted. A compilation of fully and conditionally accepted materials may be found in Informational Publication 202-1, "List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers" (List of Materials). This List of Materials can be accessed through the internet at http://www.usda.gov/rus/listof.htm. For information on technically accepted items and other questions regarding materials, please contact:

Mr. Harvey Bowles, Chair
Technical Standards Committee "A" (Electric)
Rural Utilities Service, Stop 1569
1400 Independence Avenue SW
Washington DC 20250-1569
Phone: (202) 720-0980
Fax: (202) 720-7491
Email: hbowles@rus.usda.gov

Borrowers requesting RUS approval of materials not presently accepted, for use with steel poles or any other application, are asked to provide: a description of the material, catalog sheets, test results, and the name and address of the manufacturer. Such requests should be sent to the appropriate regional Engineering Branch Chief. (See Section G)

B: LIGHTNING IMPULSE WITHSTAND STRENGTH and SURGE PROTECTION

A lightning impulse withstand strength, often called Basic Impulse Insulation Level or BIL, of less than 300 kV on distribution pole top assemblies will usually facilitate flashovers of lightning strikes to or near distribution lines. A recloser operation, which will cause lights to flicker, is usually required to clear the resulting arc. RUS advocates a minimum of 300 kV withstand strength (dry flashover, phase-to-phase and phase-to-ground) to minimize recloser operations and thus improve the quality of service. This level is especially important on deadends where voltage doubling can occur.

A withstand strength of 300 kV (dry flashover) can be achieved on steel poles by using many of the standard RUS pole-top assemblies and installing a fiberglass-reinforced plastic pole-top pin (item “b (2)” in the List of Materials) on the phase conductor attached to the very top of the pole.

A 300 kV lightning impulse withstand strength (dry flashover) can be attained on a steel pole deadend structure by installing a 24 inch (minimum length) insulated extension link (item “eu” in the List of Materials) between the primary deadend suspension insulators and the steel pole.

Borrowers do not need additional RUS approval to use the above two material items or the resulting modified standard pole top assemblies.

The designated maximum transverse load on fiberglass-reinforced plastic pole-top pins is 500 pounds. The maximum line angles for this loading limitation can be found in Table I of RUS Bulletin 1728F-803, “Specifications and Drawings for 24.9/14.4 kV Line Construction.”

RUS recommends the installation of surge arresters at 800 foot to 1,200 foot intervals and at deadends on all distribution lines, which are exposed, to frequent lightning strikes. This recommendation is especially applicable to distribution lines built with steel poles because of their generally lower lightning impulse withstand strengths. An adequate number of installed surge arresters minimizes the number of lightning flashovers and the resulting momentary outages and damaged insulators.

C. GROUNDS, GROUNDING

The National Electrical Safety Code (NESC) requires that all non current-carrying metallic members on a line support structure be effectively grounded. Thus, each steel pole needs to be effectively bonded to all primary and secondary neutrals, down guys, messengers, and all other metallic attachments to the pole. Other NESC grounding requirements may also apply.

A steel pole may be used as a grounding conductor if the pole meets the sufficient conductivity and low impedance requirements of the NESC.

Since a directly embedded steel pole is not recognized in the NESC as a grounding electrode, separate driven ground rods or grounding electrodes need to be used for all equipment, surge arresters and other required system grounds. The use of stainless steel or galvanized steel ground rods and non-copper ground wires in the soil near steel pole distribution lines will help to mitigate the corrosive effects of dissimilar metals buried in close proximity.

D: COSTS AND ECONOMIC STUDIES

RUS does not require borrowers to provide any economic studies or cost comparisons to justify the use of steel distribution poles instead of wood poles. However, borrowers are encouraged to compare the initial and long-term estimated installed cost of equivalent distribution structures or lines constructed with steel poles versus wood poles. Borrowers may, at their discretion, furnish the results of their cost estimates to RUS.

Questions or comments regarding Sections B through D above are welcomed by and should be sent to:

Jim Bohlk, Electrical Engineer
Rural Utilities Service, Stop 1569
1400 Independence Avenue SW
Washington DC 20250-1569
Phone: (202) 720-1967
Fax: (202) 720-7491
Email: jbohlk@rus.usda.gov

E: RAPTOR PROTECTION USING STEEL POLES

RUS advocates that distribution lines be designed and constructed in a way that will minimize the electrocution of raptors. Distribution construction with steel poles need extraordinary consideration because of the short distances between the bare energized phase conductors and the grounded steel pole.

On single-phase lines, the installation of 24-inch long fiberglass-reinforced plastic pole-top pins ("item b (2)" in the List of Materials) will minimize the electrocution of small raptors. On three-phase lines, some raptor protection can be achieved in an economical manner by installing fiberglass-reinforced pole-top pins and perch guards on the crossarms as shown on assembly VP3.3G in Bulletin 1728F-803.

Good raptor protection can be achieved on both single-phase and three-phase structures by:

- Installing 24-inch long fiberglass-reinforced plastic pole-top pins;
- Using non-metallic crossarms and covering the pole, from the neutral up to and including the top of the pole, with an insulating coating that has a dielectric strength of at least 15,000 volts; and,
- Using 36 inch (minimum length) fiberglass-reinforced plastic guy strain insulators (item "w") and extension links (item "eu") for all connections to the pole above the neutral position. (See Bulletin 1728F-803, assemblies VA5.4 and E5.1G)

Any questions or comments regarding raptor protection can be directed to:

Dennis Rankin
Rural Utilities Service, Stop 1571
1400 Independence Avenue SW
Washington DC 20250-1569
Phone: (202) 720-1953
Fax: (202) 720-1820
Email: drankin@rus.usda.gov

F: SELECTION OF STEEL DISTRIBUTION POLES

Generally, a wood pole cannot be replaced with a steel distribution pole of the same class because of NESC strength requirements. After the selection of the NESC grade of construction, certain "design load" calculations are required to determine the minimum class of a distribution steel pole that can be used in lieu of a wood pole for standard RUS pole-top assemblies. The calculations involve the overload factors and strength factors, for both wood and steel poles, as found in Tables 253-1 and 261-1A of the 1997 edition of the NESC. (Note that some of these values will probably be changed in the next edition of the NESC.) RUS has performed the calculations for steel pole "design loads" for various poles under 60 ft in height and not at crossings. The results are shown in the tables, which follow.

RUS regulations require a minimum of NESC Grade C construction in the design and construction of distribution lines and structures. Section 24, Grades of Construction, of the NESC, and thus RUS, may require higher grades of construction for certain conditions.

Deadend structures and line angle structures involve additional calculations (such as loading trees) to determine the required minimum steel pole strength and pole class. Thus, ***RUS advocates*** that these types of structures (and steel pole selection) be designed (1) under the direction of a registered professional engineer, and (2) meet NESC Grade B strength requirements.

The design of unguyed angle and dead-end steel pole structures should consider pole deflection and greater embedment depths. Extreme ice conditions and appropriate high winds should be considered in the design loads.

Questions or comments regarding proper selection and installation of steel poles should be sent to:

Robert Lash, Chief
Transmission Branch
Rural Utilities Service, Stop 1569
1400 Independence Avenue SW
Washington DC 20250-1569
Phone: (202) 720-0486
Fax: (202) 720-7491
Email: blash@rus.usda.gov

or

Donald Heald, Engineer
Rural Utilities Service, Stop 1569
1400 Independence Avenue SW
Washington DC 20250-1569
Phone: (202) 720-9102
Fax: (202) 720-7491
Email: dheald@rus.usda.gov

Required Steel Pole Design Loads

(Columns 1 and 2 from American National Standards Institute (ANSI 05.1)
(Design loads 2 feet from top of pole)

TABLE 1 - NESC GRADE C STRUCTURES (RUS Tangent and Small Angle Assemblies) (Not at a Crossing) (For New and Replaced Grade C Structures)		
ANSI 0.51 Wood Pole Class	**Wood Pole Design Load (lbs.)**	**Steel Pole Design Load (lbs.)**
H1	5400	5770
1	4500	4810
2	3700	3960
3	3000	3210
4	2400	2570
5	1900	2030
6	1500	1600
7	1200	1290

TABLE 2 - NESC GRADE B STRUCTURES (RUS Tangent and Small Angle Assemblies) (Not at a Crossing) (For New and Replaced Grade B Structures)		
ANSI 0.51 Wood Pole Class	**Wood Pole Design Load (lbs.)**	**Steel Pole Design Load (lbs.)**
H1	5400	3510
1	4500	2930
2	3700	2410
3	3000	1950
4	2400	1560
5	1900	1240

G: REQUEST FOR RUS APPROVAL TO USE STEEL DISTRIBUTION POLES

Borrowers requesting RUS approval to use steel distribution poles should send their written request and supporting information to the appropriate regional Engineering Branch Chief at the address given below.

Northern Region	Southern Region
Charles M. Philpott, Chief Northern Engineering Branch Rural Utilities Service, Stop 1566 1400 Independence Avenue SW Washington DC 20250-1566 Phone: (202) 720-1432 Fax: (202) 720-1411 Email: cphilpot@rus.usda.gov	Louis Riggs, Acting Chief Southern Engineering Branch Rural Utilities Service, Stop 1567 1400 Independence Avenue SW Washington DC 20250-1567 Phone: (202) 720-0848 Fax: (202) 720-0097 Email: lriggs@rdmail.rural.usda.gov

Part II: Information Needed by RUS for Case-by-Case Approval of Steel Distribution Poles

Before granting approval, RUS needs all of the information requested below to determine if the steel pole application will result in safe and reliable construction and meets all of RUS's requirements.

1. Indicate the maximum number of steel poles to be used.

2. Indicate the name of the steel pole manufacturer.

3. Define the project or location(s) where the steel poles will be installed.

4. In addition to "experimental purposes to obtain experience", furnish sound reason(s) for using steel poles.

5. Indicate that only RUS accepted materials are to be used. *(Otherwise, see Section A of steel pole guidelines.)*

6. Indicate that only RUS standard construction is to be used. *(Otherwise, see Sections A and B of steel pole guidelines. Please furnish sufficient dimensioned drawings and other technical information for RUS' evaluation of the design.)*

7. *(If, and only if, the design has less than a 300 kV withstand strength [see guidelines, Section B], then briefly describe assemblies and materials to be used and anticipated impact [if any] on reliability and materials.)*

8. Describe raptor protection measures, if any, that are to be incorporated into the design. *(See guidelines, Section D.)* *(Note that RUS recommends that raptor protection be considered in distribution line designs, especially lines using steel poles, even though neither all lines nor all areas may require raptor protection.)*

9. Indicate that the determination of the class of the steel poles for each application is based on the proper engineering calculations performed by a competent person. *(See guidelines, Section F.)*

BIOGRAPHICAL SKETCH

H. ROBERT LASH

H.Robert Lash is presently Chief of the Transmission Branch, Electric Staff Division. In this position he supervises the review of transmission line designs, substation designs, contract and policy review and revision, and other technical areas of support for the area offices. Bob is a member of IEEE, and American Wood Preservers' Association and sits on several ANSI subcommittees.

Prior to gaining RUS in 1983, Bob was employed by Burns & McDonnell Consultants and Joslyn Manufacturing.

He graduated from Kent State University in 1980 with a MBA and SUNY College of Environmental Science and Forestry in 1974 with a BS in Wood Products Engineering.

NORRIS NICHOLSON

Norris Nicholson is an electrical engineer employed in the Electric Staff Division of the Rural Utilities Service. Mr. Nicholson began his career with the Rural Electrification Administration in 1993 as an intern student with the Automated Information Systems Division. He has been working in the Transmission Branch of the Electric Staff Division over the past year in developing agency guidelines and standards for use by RUS engineers, borrowers, and their consulting engineers. He is active in the Electric Engineering Committee of RUS. Mr. Nicholson obtained his BSEE from Southern A & M College and University, Baton Rouge, Louisiana.

ALTERNATIVES
TO
WOOD POLES
AND CROSSARMS

(MARCH 14, 2000)

Hot Topic

Light Duty Steel Poles and Fiberglass Crossarms

Light Duty Steel Poles

- Not promoting wide spread substitution
- Are advantageous under certain conditions

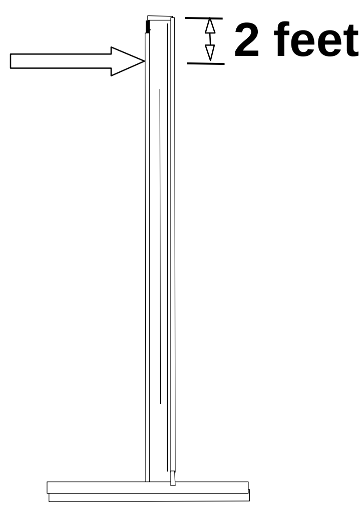
Wood Pole Costs

- Harvesting Restrictions
- Supply & Demand
- Preservative Costs

Steel Pole Designs

- Originally designed using loading trees
- Offered in pre-engineered classes
- Published transmission class pole values

TIP LOAD



Wood Pole Equivalency

- Difficult because of inherent differences in materials

Steel Distribution Poles

Pros	Cons
Long Life	No Long-term Experience
Lighter Weight	Lack of Linecrew Experience
Lower Construction Cost	Harder to Field Drill
No Defects	Difficult to Repair
Low Maintenance	Conductivity

Wood Poles

Pros	Cons
70 Years of Experience	Decay
Field Framing	Disposal
Repair	Weight
Conductivity	Preservatives

Comparison of Materials

Many intangibles to consider

RUS Concerns

Direct Substitution Using
Pre-Engineered Classes

Grade "B" Construction

Transverse Loads

		Overload Factor
Wood	-	4.0
Steel	-	2.5

Wood Equivalent Steel Poles
Grade "B" Construction

Pole Class	*Wood Tip Load*	*Steel Tip Load*
1	*4500*	*2925*
2	*3777*	*2405*
3	*3000*	*1950*
4	*2400*	*1560*
5	*1900*	*1235*

Grade "C" Construction

Transverse Loads

		Overload Factor
Wood	-	2.67 at crossings 2.0 not at crossings
Steel	-	2.20

Wood Equivalent Steel Poles
Grade “C” Construction

Pole Class	*Wood Tip Load*	*Steel Tip Load*
1	***4500***	***4810***
2	***3777***	***3960***
3	***3000***	***3210***
4	***2400***	***2565***
5	***1900***	***2030***

Example:

Wood Pole Design

Base Pole - 40ft. Class 4

Grade “C” Construction

Horizontal Tip Loads

- Wood Tip Load - 2400 lbs.
- Steel Tip Load - 2565 lbs.

Pole Selection from Transmission Tables

2565 lbs.- Class 1

Class 4 from same table 40% undersized

Distribution Steel Poles

Electrical Effects

Wood Poles

RUS standard pole top assemblies with wood poles - lightning impulse withstand of 350-499 kV

When using steel poles

RUS advocates minimum lightning Impulse withstand around 300 kV

When using steel poles

Withstands strengths around 300 kV could facilitate flashovers of lightning strokes

When using steel poles

Recloser operation needed to clear resulting arc-Lights flickers

When using steel poles

Need approximately 300 kV withstand for acceptable quality of service

When using steel poles

RUS recommends surge arresters or fiberglass pole top pins to increase withstand.

When using steel poles

NESC does not recognize direct embedded steel pole as a grounding electrode

When using steel poles

RUS and NESC require a separate driven electrode for all equipment, surge arresters and required system grounds

Believe it or not!!!!!!

RUS has streamlined

Case-By-Case

Approval

Information Needed by RUS

- Number of Steel Poles
- Location of Installation

Information Needed by RUS

- Steel Pole Manufacturer
- Justification-
  usually to “gain experience”

Information Needed by RUS

- Statement if RUS standard pole top assembly is bring used
- Statement concerning the use of RUS accepted materials

Information Needed by RUS

- Statement on method used to achieve acceptable lightning withstand strength
- Assurance that steel pole was selected using proper engineering calculations

Information Needed by RUS

- If non-standard pole top assembly is to be used:
  - Dimensional Drawings
  - Technical information to evaluate

Information Needed by RUS

- If “unlisted” material are to be used:
  - Detailed description of material for evaluation

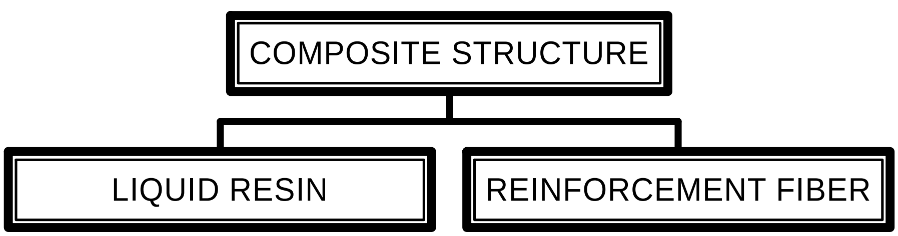
Information Needed by RUS

- Statement that Raptor protection was considered and what measures are being taken

ALTERNATIVES TO WOOD CROSSARMS

Norris W. Nicholson
Electric Staff Division-Transmission Branch

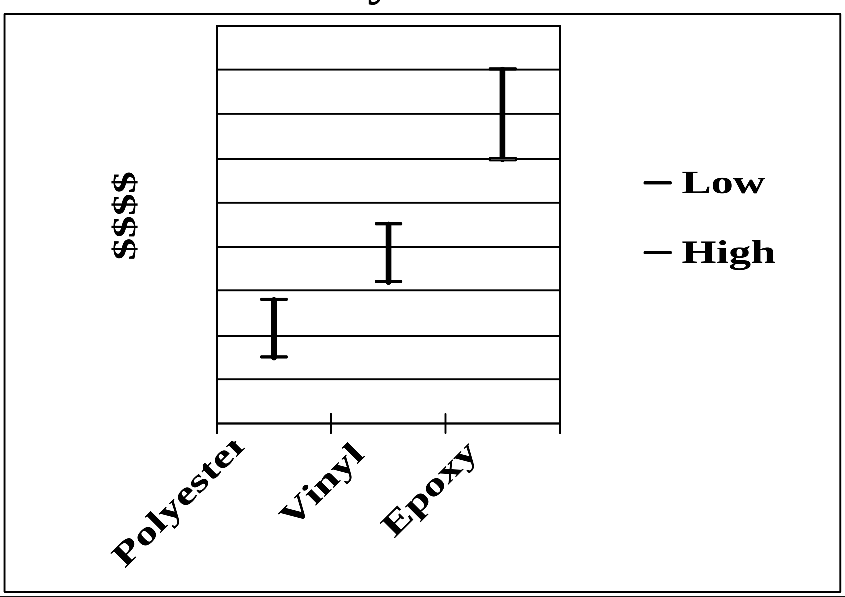
Physical Makeup



Major Resin Groups

- Polyester
- Vinylester
- Epoxy
- Acrylic
- Urethane
- Phenolic

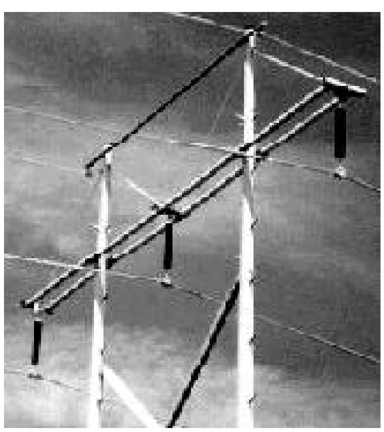
Resin System Costs



Reinforcement Fibers

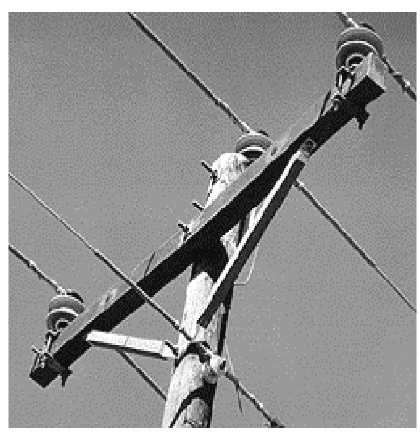
- Kevlar
- Carbon
- Glass

Transmission & Distribution



115 kV

Transmission Assembly



15 kV

Distribution Line

<u>Advantages</u> & <u>Disadvantages</u>

Advantages	Disadvantages
➡ Weight	➡ Deflection
➡ Application	➡ Blooming
➡ Insect/Bird Resistance	➡ Cost

Basic Guidelines

- ➡ Same load capacity as the standard wood crossarm
- ➡ Same cross section as the wood crossarm
- ➡ Same environmental exposure requirements as the wood crossarm

ITEMS REQUIRED IN AN APPLICATION FOR RUS ACCEPTANCE
OF FIBERGLASS CROSSARMS

1. **Test Requirements:**
   - Vertical and longitudinal crossarms tests - The fiberglass crossarms should meet or exceed ultimate moment capacity and deflection characteristics of equivalent wood arms for of each major axis (wood crossarm based on an MOR of 7400 psi and MOE of 1.8×10^6 psi) . Test crossarms in accordance with ANSI 05.3 – 1995 Annex B.
   - Transverse Pin Test
     a. Transverse load to be applied to a 1-3/8" thread pin (item f) with a 2 1/4" washer mounted on the fiberglass crossarm.
     b. No crushing of the fiberglass member is permitted for a transverse load up to 750 lbs transverse load.
     c. Transverse load to be gradually increased to 1650 lbs or ultimate, whichever comes first. Report results.
   - Longitudinal Pin Test - Apply 700 lbs to a 1 3/8" thread pin (item f) with a 2 1/4" washer in the longitudinal direction.
   - Electrical Test - Perform a dry flashover test between the crossarm mounting hole and the farthest end pin hole. Report the results.
   - Weathering and Aging Tests - Crossarms shall be tested for accelerated weathering and ultraviolet aging for 2500 hours without any deterioration in accordance with ASTM G53, *Practice for operating light-and water-exposure apparatus (fluorescence UV - condensation type) for exposure of non-metallic materials;*

2. **Design Requirements:**
   - Arms shall be equivalent in size to RUS standard size wood arms;
   - Crossarm must be able to be field drilled through the center line of each major axis;
   - Attachment method of the crossarm to the pole must be consistent or same as wood the crossarm;
   - Crossarms shall be designed for a minimum of 30 years of exterior exposure.
   - Crossarms shall be foam-filled to eliminate water ingress. Filler shall be closed cell and completely fill the crossarm. End caps shall be permanently affixed;
   - Each crossarm shall be permanently marked with the manufacturer’s name or logo and date of manufacture.
   - Crossarm shall be designed for a minimum crushing load of 500 psi under washer without any permanent deformation or damage.

Refer to “General Requirements in an Application for RUS Acceptance of a Product” for additional information.

Design
Items Required

- Equivalent to standard size RUS crossarms
- Consistent pole attachment
- Field drillable
- Foam filled
- Minimum 500 psi washer crushing load
- Minimum 30 yrs. exterior exposure
- Permanently marked

Test
Items Required

- ➡Vertical & Longitudinal
- ➡Transverse Pin
- ➡Longitudinal Pin
- ➡Electrical
- ➡Weathering & Aging

Vertical & Longitudinal Test

- ➡Modulus of Rupture (MOR)
  - ➢7400 psi
- ➡Modulus of Elasticity (MOE)
  - ➢1.8×10^6 psi

(ANSI 05.3 - 1995 Annex B)

Transverse Pin Test

- ➡1650 lbs. Or ultimate transverse moment
- ➡750 lbs. Crushing withstand

Longitudinal Pin Test

700 lbs. Load to 1 3/8” thread pin with 2 1/4” washer

Electrical Test

- ➡Dry flashover

Weathering & Ultraviolet Test

2500 hours ultraviolet aging & accelerated weathering

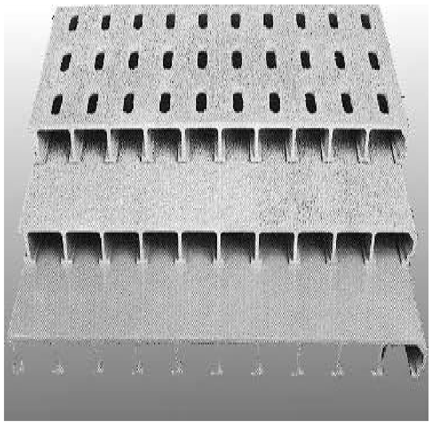
(ASTM G53)

Other

Applications

Substations

Decking



Walkways

Bridges