UNITED NATIONS

ECONOMIC
AND
SOCIAL COUNCIL

LIMITED

ST/ECLA/CONF.7/L.2.5
5 January 1961

ORIGINAL: ENGLISH

LATIN AMERICAN ELECTRIC POWER SEMINAR

Held under the joint auspices of the Economic
Commission for Latin America, the Bureau of
Technical Assistance Operations and the
Resources and Transport Economics Branch
of the United Nations, with the collaboration
of the Government of the United Mexican States

Mexico City, 31 July to 12 August 1961

Vol. III

CHARACTERISTICS, DESIGN, CONSTRUCTION AND OPERATION OF RURAL ELECTRIC SYSTEMS IN THE UNITED STATES

by John H. Rixse, Jr.

Note: This text is subject to editorial revision.

CHARACTERISTICS

OF

RURAL ELECTRIC SYSTEMS

DESIGN, CONSTRUCTION AND OPERATION

IN THE

UNITED STATES

Prepared By

John H. Rixse, Jr.
September 1960

for

LATIN AMERICAN ELECTRIC POWER SEMINAR
MEXICO CITY
January 16 - 18
1961

OUTLINE

ILLUSTRATIONS

CHARACTERISTICS
of
RURAL ELECTRIC SYSTEMS
Design, Construction and Operation
in the
United States

I

PREAMBLE

THE RURAL ELECTRIC SYSTEM,[1] a unique part of American agriculture and the electric utility industry, has been a significant factor in the expansion of agricultural production, in improving rural living, and in economizing electric power distribution system construction costs.

The pattern which the development of these systems followed was adapted to the specific problems and conditions in the rural areas of the United States. The principles involved, however, were universal and have application to other conditions and problems. The basic objective has been the provision of central station electric service to all rural consumers at a cost which would stimulate increasingly wider and greater usage of electrical energy.

The organizations and financial arrangements reflect the private ownership and initiative inherent in agricultural and industrial growth in the United States. The technological considerations were based upon the universal and professional viewpoint of the engineers, which were to constantly strive to do a better job - more efficiently, more effectively and more economically.

The purpose of this paper is to provide some insight into the conditions, considerations and actions which have been integral characteristics of the design, construction and operation of the rural electric systems in the United States. The extent to which these are set forth, so that the reader who has a differing set of conditions and problems can find ideas for adaption, will determine if this paper has achieved its purpose. The subject matter will be reviewed from nine different viewpoints in the following sequence: (1) description; (2) participants; (3) development; (4) standards; (5) financing; (6) design; (7) construction; (8) operation and maintenance; (9) planning. Frequent reference is made to an extensive bibliography rather than to recite many details herein. The reader can get an overall perspective from this paper, leaving detail study of the reference material to his choice and to those who may have responsibility for more intensive use of this material.

II

DESCRIPTION

To better understand the characteristics of rural electric systems, as they relate to economical design, construction and operation, we need a common understanding of terminology and of the systems. To provide that understanding is the purpose of this section.

A. Definitions

The term "rural electric system" as used herein refers primarily to those electric distribution properties which have been financed by the Rural Electrification Administration (REA). Some have moderate amounts of transmission and generation facilities.

To clearly understand the nature of the rural electric systems it should be noted that farmers in the United States live on their farms. When the systems were first developed most families living in rural areas were living on farms and were engaged almost exclusively in farming. Today many families living in rural areas do not farm and they make their livelihood from rural industries or in nearby towns. The rural town is primarily a trading center for the farmer. A large percentage of the towns receive central station electric service from the commercial power companies.

The rural areas not served by the rural electric systems are served by rural extensions of the urban and suburban systems of the commercial power companies.

B. Magnitude

These systems serve approximately one-half of the consumers in rural America. They serve 55% of the farms. They are relatively small; all are less than 25 years old; and the weighted age of all facilities is approaching 12 years. There are 1087 such systems operating 1,500,000 miles of line serving about 5,000,000 farms, rural non-farm residences and rural industrial establishments. They borrowed about $4,000,000,000 from the Federal Government - 76% of these funds are invested in the distribution plant; 12% in generation; 12% in transmission.[2]

C. Electrical Characteristics [3]

The rural electric system in the United States is basically a 7200/12,470-volt, multi-grounded, common primary-secondary neutral, 60-cycle distribution system from which the consumers are served single phase directly through distribution transformers at 120/240 volts, three-wire. The 7200-volt distribution line is brought within 200 feet of the load center of each farm. One service wire is grounded, the other two wires are 120 volts above ground. A comparatively small percentage of farms require three-phase service primarily for irrigation pumps or other large motor loads. These are usually provided 240 or 480-volt, three-phase three-wire service.

In sparsely settled areas a distribution system employing 14,400/24,900-volt, multi-grounded, common primary-secondary neutral, 60-cycle is sometimes used. The 40,000 miles of line at this voltage constitute less than 3% of the total.

A typical distribution system would consist of approximately 20% of three-phase, 10% of two-phase and 70% of single-phase circuits. The three-phase and two-phase are used primarily for the purpose of providing load carrying ability. Practically all loads are served at single-phase.

Transmission lines are generally 69 kv grounded wye. Some 33 kv and 46 kv was used so as to provide short extensions from, or interconnections with, the power suppliers' facilities. Some 115 kv to 230 kv transmission lines are now also utilized.

The basic impulse level of equipment used on the 7.2/12.5 kv system is 95 kv, except for certain heavy-duty power equipment which is rated at 110 kv. Insulators are rated at 65 kv dry flashover, 35 kv wet flashover, with a positive impulse flashover voltage of 100 kv. In contaminated areas special insulation is used.

The equipment used on 14.4/24.9 kv systems has a basic impulse level of 125 kv, except for automatic circuit reclosers and substation equipment which are rated at 150 kv. Line insulators have a 60-cycle rating of 95 kv dry flashover and 60 kv wet flashover and have a positive impulse flashover value of 150 kv.

The REA-financed generating facilities[4] aggregate approximately 1,650,000 kw installed capacity. Included in this is a range of diesel, hydro and steam plants. Individual unit sizes range from 100 to 100,000 kw. The small sizes are principally those in isolated locations such as islands and portions of Alaska. The more recent units are generally steam, the average being 33,000 kw.

D. Physical Characteristics

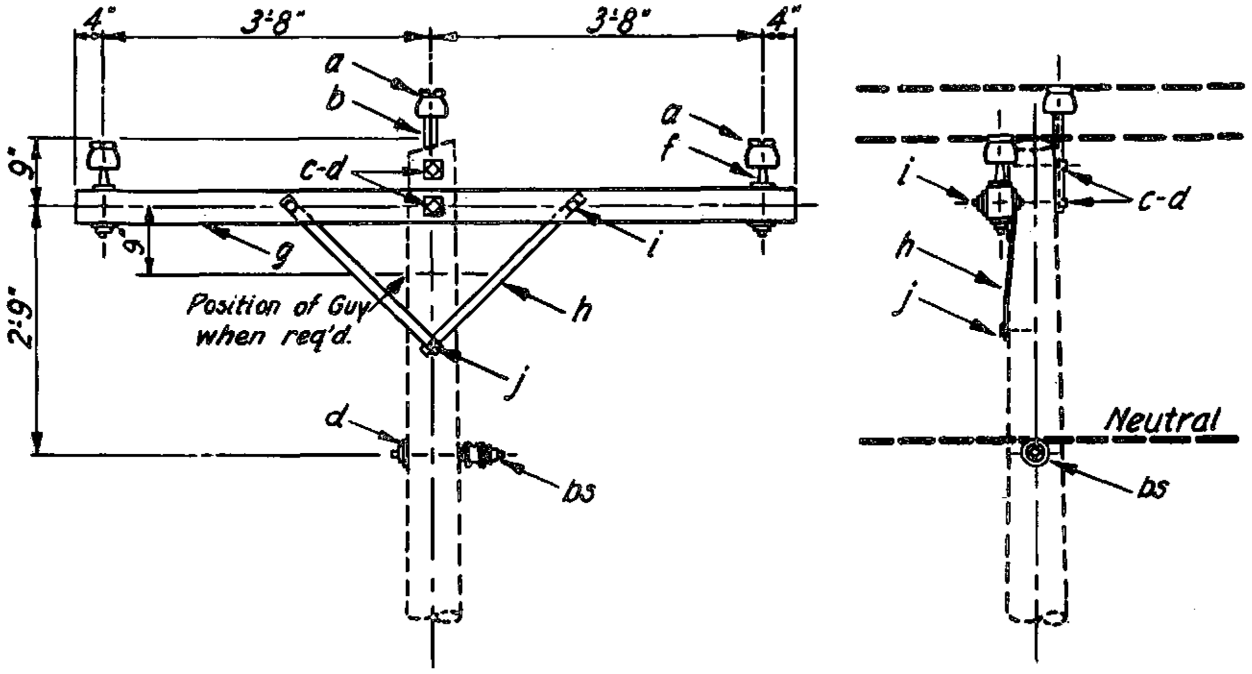
The dominant physical characteristic of rural system construction is the use of high strength conductors and simplified pole top structures.

For the distribution system, 30, 35 and 40 foot wood poles, ranging from 10 to 13 per mile, (extremes of 8 and 17), support high strength copperweld copper or ACSR primary conductor in sizes ranging from No. 6 to 1/0 AWG copper equivalent. The single-phase lines carry the primary conductor on a ridge pin insulator with the neutral 40 inches below attached to the pole with a bracket. Figures 1[5] and 2[5] illustrate a tangent single-phase (A1 assembly unit) and three-phase pole top configuration (C1 assembly unit) for 7.2/12.5 kv. Figure 3[6] illustrates a 14.4 kv tangent single-phase pole top configuration (VA1 assembly unit).

The transmission lines are similarly designed. Liberal use is made of single pole suspension type construction as illustrated in Figure 4[7] (TS-1 assembly unit).

Substations are either packaged or custom designed. They are compact, employing a minimum of equipment. Capacities are in the range of 500 to 1500 kva. Most substations are equipped with three single-phase power transformers plus a spare, but there is a trend toward the use of three-phase power transformers.

The requirements of the National Electrical Safety Code (NESC)[8,9] provide the basic safety considerations in the design of each line. If a local government has a more stringent requirement than the NESC, then the local requirement prevails.



ITEM	No. REQ'D.	MATERIAL		ITEM	No. REQ'D.	MATERIAL	
a	3	Insulator, pin type		g	1	Crossarm, 3½"×4½"×8'-0"	
b	1	Pin, pole top, 15"		h	2	Brace, 1¼"×¼"×28"	
c	2	Bolt, machine, 5/8"×req'd. length		i	2	Bolt, carriage, 3/8"×4½"	
d	3	Washer, 2¼"×2¼"×3/16", 13/16" hole		j	1	Screw, lag, ½"×4"	
bs	1	Bolt, single upset, insulated					
f	2	Pin, crossarm, steel, 5/8"×10¾					

FIG. 2

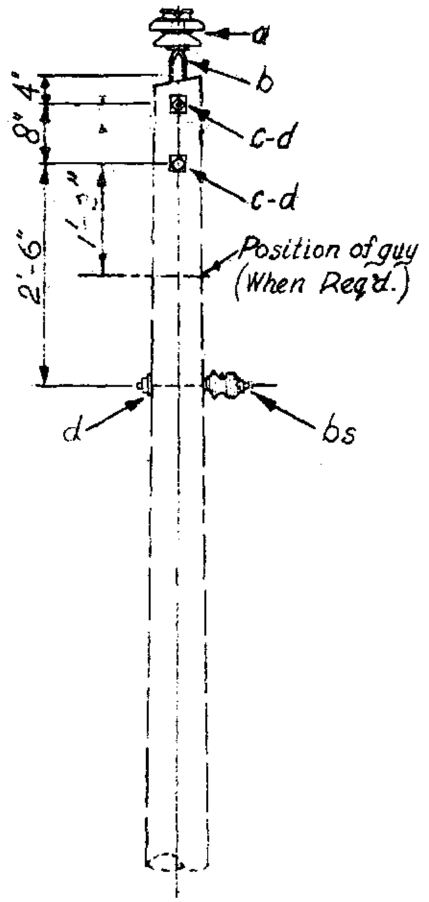
7.2/12.5 KV. PRIMARY, 3-PHASE 4-WIRE STAR
CROSSARM CONSTR.—SINGLE PRIMARY SUPPORT AT 0° TO 5° ANGLE

Scale: ½"=1'0"

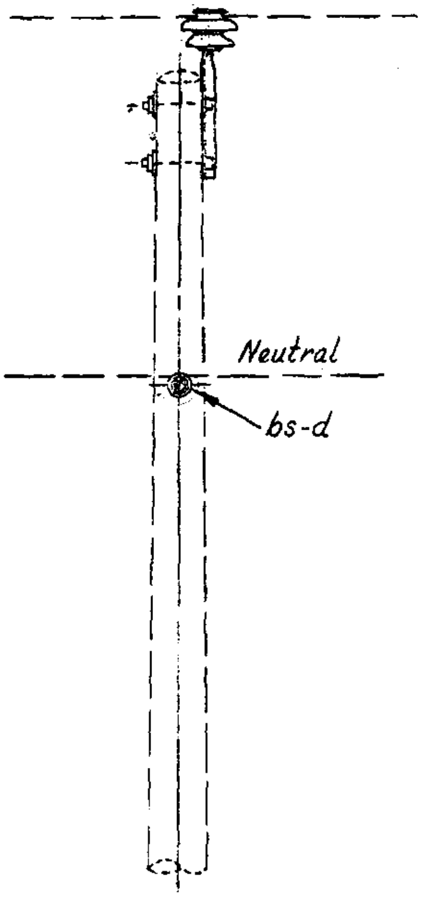
Date:

C1

NO.	REVISION	DATE
1	Reissued	8-56



ELEVATION



SIDE ELEVATION

ITEM	No. Req'd	MATERIAL		ITEM	No. Req'd	MATERIAL	
a	1	Insulator, pin type		d	3	Washer, 2¼" x 2¼" x 3/16", 13/16" hole	
b	1	Pin, pole top, 20"		bs	1	Bolt, single upset, insulated	
c	2	Bolt, machine, 5/8" x req'd. length					

FIG. 3

14.4/24.9kV PRIMARY, 1-PHASE 2-WIRE, NEUTRAL GROUNDED
VERTICAL CONSTR.-0° TO 5° ANGLE-SINGLE PRIMARY SUPPORT.

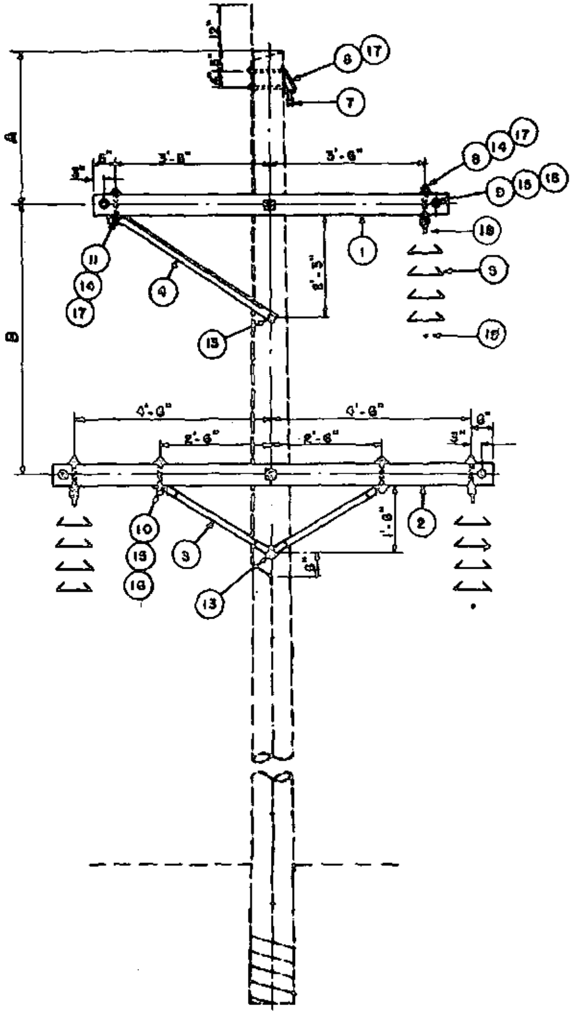
Scale ½"-1'-0"

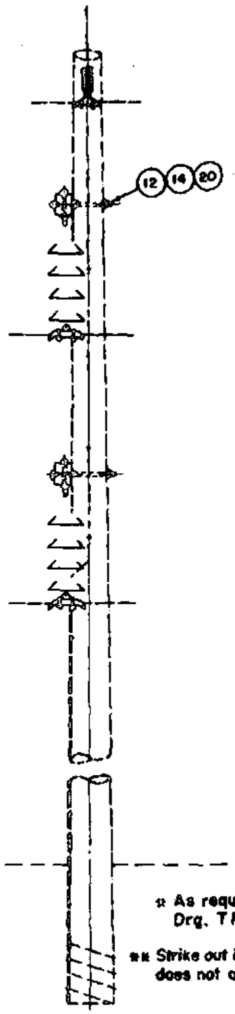
Date: July 19, 1949

VA1

NO.	REVISION	DATE:
1	Reissued	12-56

NOTE:
On Straight Lines Items 6 and 7
May be Mounted On Opposite
Side Of The Pole.





* As required. See Drg. TM-I

** Strike out item which does not apply.

DRG. NO.	DIMENSIONS	
	A	B

LIST OF MATERIAL

	DRG. REF.	REQ'D	DESCRIPTION	ITEM
	1	1	4 3/4"x5 3/4"x8'-0" Wood Crossarm	a
	2	1	4 3/4"x5 3/4"x10'-0" Wood Crossarm	a
	3	1	60" Wood Crossarm Brace	eu
	4	1	48" Alloy Arm Brace	em
	5	*	5 3/4"x10" Suspension Insulator	k
	6	1	Ground Wire Cable Support	ad
	7	1	Ground Wire Suspension Clamp	m
	8	3	5/8"x8" Eye Bolt	o
	9	4	1/2"x7" Machine Bolt	c
	10	2	1/2"x8" Machine Bolt	c
	11	1	5/8"x8" Machine Bolt	c
	12	2	3/4"x18" Machine Bolt	c
**	13	2	5/8"x 5" Lag Screw or 5/8"x12" Mach. Bolt & Locknut	j
	14	11	2 1/4"x 2 1/4"x 3/16" Galv. Sq. Washer, 13/16" Hole	d
	15	10	1 3/8" Galv. Round Washer, 9/16" Hole	d
	16	6	Locknuts for 1/2" Bolt	ak
	17	6	Locknuts for 5/8" Bolt	ak
	18	3	Suspension Hook	ah
	19	3	Suspension Clamp and Connecting Piece	al
	20	2	Locknuts for 3/4" Bolts	ak

FIG. 4

TRANSMISSION LINE TANGENT STRUCTURE
____ KV. SINGLE POLE SUSPENSION
(69 KV. MAXIMUM)

III

PARTICIPANTS

The rural electrification program, as the development, construction and expansion of these rural electric systems is known, involves as active and effective participants several different groups of people. To better understand their roles, we should briefly review the nature and function of each. These participants, as we shall call them, are the management of the system, REA, engineer, contractor, power supplier and material manufacturer and supplier.

A. System Management

Each rural electric system is a local independently-owned and managed enterprise.[10] Of the 989 active borrowers, 929 are cooperatives, 43 are public power districts, 13 are municipals and other public bodies, and 4 are power companies.

The power companies are private, investor-owned, profit-making public service corporations. The municipal systems and the public power districts both represent public ownership enterprises which are supported by local taxing authority. The cooperatives are non-profit, locally organized systems owned by their members and managed through a board of directors elected by the members. Generally one thinks of a cooperative as being the most representative type of rural electric system.

The management of each of these systems is responsible for obtaining the necessary financing and for the design, construction, operation and maintenance of its system.

B. Rural Electrification Administration

The Rural Electrification Administration (REA)[10] was established by Executive Order of the President in 1935. It was created as part of the Federal Works Program to relieve unemployment. REA was transformed, in its first year of operation, into a lending agency with the task of accomplishing nation-wide rural electrification. All loans have been on an interest-bearing self-liquidating basis.

REA does not own nor operate electric facilities. Its functions are to lend money for electric facilities to serve rural areas;[12,13] to enable its borrowers to finance consumer wiring, appliances, equipment and plumbing;[14] and to assure repayment of loans through appropriate loan security activities. REA can lend 100% of the funds required and takes a first mortgage on the facility. The loans bear 2% interest, are for a period not to exceed 35 years, and are repaid from the operating revenues of the borrowers.

To assure repayment of loans, REA makes feasibility studies of loan applications and establishes standards to assure security in the use of funds and in the design, construction, operation and maintenance of the facilities.

C. Engineers[15]

All REA facilities are designed by private consulting engineers, or engineers on the payrolls of the rural electric systems. The "consulting engineers" also undertake other types of engineering services for the systems, e.g., construction supervision, operations, maintenance, planning, preparation of loan applications, power supply analyses and mapping. Both the consulting and the payroll engineers are generally referred to as "system engineers".

D. Contractors[16]

Facilities of the rural electric systems are constructed by independent private contractors, or by the systems' own forces. Initially, facilities were generally constructed by contractors. This is still true with respect to major additions and extensive changes in the system facilities. The crews of the rural electric systems are utilized for maintenance, short extensions, and, in some cases, extensive construction. The general pattern of economic construction has been through effective utilization of the contractor.

E. Power Supplier[17]

Eighty-five percent (85%) of the power distributed by the rural electric systems is purchased, the remainder is self-generated. Of the 85% that is purchased, power companies supply 41%, Federal agencies supply 37% and other public agencies supply 7%. The cost of power varies widely in different parts of the United States. Average wholesale power costs have been reduced from 10 mills in 1941 to 7.0 mills in 1959. It is the largest single item of expense; as a percentage of all operating expenses, wholesale power is becoming increasingly important.

F. Material Manufacturers and Suppliers[16]

Material manufacturers and suppliers, generally referred to as "suppliers", represent a private-industry undertaking. The materials supplied are generally those commercially available, fabricated and produced under national standards. A mass market for rural line construction materials prompted the suppliers to make available items of material and equipment designed for this specific use. Where industry standards are not directly applicable, the materials are produced under REA standards[10] which frequently incorporate national standards, in whole or in part, by reference. The materials which suppliers can provide to the rural electric systems have been reviewed and found to contain the minimum physical and electrical characteristics required for the job.[19] Materials are purchased as a result of formal bidding, manufacturers' quotations, or, on direct order.

IV

DEVELOPMENT

The rural electric system, a now well-defined entity and an important segment of the electric power industry in the United States, did not develop overnight. It is the result of an evolution of ideas both technical and administrative. This evolution or development from concept to reality can be described best by briefly considering three phases or eras of development--initial, up to 1940; intermediate, 1940-1960; and, present.

A. Initial

Prior to 1935 the few rural lines which were providing central station electric service to the 10.9% of the farms in the United States were along main roads, interurban electric railway lines and short extensions from towns. The initial construction of the rural electric systems, commencing in 1935, consisted basically of building strictly rural lines. These lines were extensions of the facilities of the power companies from which power was purchased or from small, frequently single phase, substations provided by the power company. As each facility was designed and constructed, it was thought of as a line, usually single-phase, 7200 volt. All persons in the immediate area through which the line was being built were solicited to become members of the cooperative, and were provided service if they joined and paid the membership fee.

Materials and equipment which were available at that time were used. These involved two-bushing transformers, flat crossarm construction, insulated guys, etc. From the standpoint of cost, the early electric lines would cost $2,000 or more per mile. This was prohibitive. Immediate advantage was taken, however, of developments, which had immediately preceded 1935, utilizing the single-bushing transformer, vertical construction and high-strength conductor. This permitted costs averaging $1,000 per mile. The introduction of mass construction methods, which is discussed later, permitted the reduction of costs to as low as $500 per mile in the late 1930's and early 1940's.

B. Intermediate

As the desire of rural consumers for central station electric service grew and as the ways and means of providing this service were developed, it became evident that systems needed to be built not just lines. This period, which gained considerable momentum during the late 1940's following World War II, brought about the construction of transmission lines, substations and integrated distribution systems. Economies of design, operation and maintenance were attained. Lower wholesale power costs also were realized.

C. Present

Today, the rural electric systems in the United States, as independent entities, form a distinct, yet integral, part of the electric power industry. They have gone beyond the development stage and have pioneered in long-range system planning, improved operating techniques, and obtained needed improvements in equipment and materials while continuing to lower the cost to the consumer from 5.06 cents in 1941 to 2.39 cents in 1959.

V

STANDARDS

The development of the rural electric systems, the extensive construction, and the lowering of costs on a nation-wide basis were enhanced through prudent and consistent use of standards. Frankly, standards were a necessity. Further, the standards had to be dynamic reflecting the vast experience gained with progress.

Standards applicable covered many fields--system, lines, structures, materials and equipment, contracts, and relationship and procedures. This section discusses standards in these areas of interest.

A. Systems

As a condition to making a loan, the REA established and has maintained standards for rural electric system design. These are general and broad in terms of overall feasibility, serving all consumers within the area in which facilities are to be constructed, utilization of competent engineering personnel, and construction at the lowest practicable costs--usually as a result of competitive bidding. These broad guidelines require that there be adequate funds available to complete the anticipated work and that the work be accomplished and certified to in accordance with accepted accounting and engineering practices. It is at this point that the National Electrical Safety Code (NESC)[9] is a requirement.

B. Lines

The individual lines are also subject to prescribed REA standards. These include a maximum voltage drop of 7 percent in the primary line, 2 percent in the secondary and service, and 3 percent in the transformer.[20] Further, each line is to be designed according to economic conductor size determinations.[21] Routing is to be, insofar as practical, on private rights-of-way so as to minimize future changes owing to road widening. Sectionalizing guidelines are provided to optimize service restoration and to minimize consumer outages.[22,23]

C. Materials and Equipment

Materials and equipment incorporated in REA-financed lines must have been reviewed and found to be satisfactory.[19] In this, national and industry standards are observed, except where they have been found to be inadequate. In the latter case, REA standards are established and used.[16] Each item of material is reviewed as to its design, physical and electrical characteristics, service experience and ability to meet the service conditions to which it will be exposed. Items found to be satisfactory are listed. This review and listing is accomplished by an independent, constantly changing committee of anonymous engineers.

D. Contracts

Standard engineering and construction contracts have been developed and are used.[16] These provide for uniformity of requirements and procedures, thus facilitating lower costs.

E. Relationships and Procedures

The mutual responsibilities of suppliers, engineers, contractors, rural electric system management and REA in regard to standards have been well established and are well understood. They are respected by all segments of industry. They provide for mutual protection and benefit. The procedures associated with the revision of standards and the application of standards provide a continuity that has kept costs to a minimum.

VI

FINANCING

Financing played an important role in the development of rural electric systems. The salient features include feasibility, REA loans and general funds.

A. Feasibility

Each individual piece of construction when considered with other existing facilities in light of present and projected loads must be economically feasible. This feasibility test has been an integral part of the development of the rural electric system since its inception in 1935. Feasibility, i.e., the ability of the revenue from the facilities to permit repayment of all capital investment, is a unique characteristic of the rural electric system. Upon completion of a mortgage period, all debt will have been liquidated. If facilities cannot meet this test, they are not undertaken.

B. REA Loans

Initially REA loaned 100% of all financial requirements for the rural electric system. Today, the systems invest some of their own funds. When funds are required of REA, an engineering design analysis and estimate are developed. This is principally to determine the approximate cost. The engineer and the system management develop their estimates of future energy usage, both in terms of individual usage and the number and type of consumers. Analyses are made of the cost of power and of operation and maintenance and other administrative expenses. All of these data are put together into a logical presentation and submitted to REA. REA must make its own analyses as to feasibility. A finding that a loan request, together with all previous loans, will be feasible and can be repaid is sufficient for funds to be loaned and advanced. All funds loaned are not immediately advanced. Funds are drawn down by the rural electric system only as required. Interest commences the moment the money is drawn.[12]

C. General Funds

As the rural electric systems have grown, increasing their net worth from zero to 18%, they have had more and more general funds derived from revenue available for investment in their own systems. When a system desires to have these general funds reimbursed, it applies for a loan which is evaluated in the same manner as a loan for initial construction.

VII

DESIGN

The design of rural electric systems' individual facilities, as well as the whole system, involves a number of unique characteristics. These characteristics are best disclosed by considering loads and service areas, plans and specifications, and supporting data.

A. Loads and Service Areas

The design of any electric system assumed knowledge of or competency in several areas:

1. Estimating loads
2. Equipment
3. Construction techniques
4. Estimated life of facilities
5. Future system requirements and capacity

In the development of the rural electric system in the United States, the estimating of loads has been approached in two general ways. The first was unscientific and embodied a great deal of faith. The second, and present method, embodies scientific methods enhanced by extensive experience and good forecasters.

Annual consumption for an individual family in a rural area in 1926 averaged 586 kwh. The engineers designing the original rural electric lines used 60-90 kwh per month, or 720-1080 kwh per year, as their design load per farm. This rate of less than 50 kwh per month was representative of the area east of the 100th Meridian, which contained little or no irrigation pumping. It is noteworthy to record that these estimates of farm usage were based only on a few farms near towns and Agricultural Experiment Station projects. Concurrent with the design and construction of the initial lines went an intensive educational program to encourage effective use of electricity.

These usage estimates ranging about 1,000 kwh per year proved inadequate within a few years. Fortunately the period of World War II brought the extension of rural lines to a virtual standstill. When the floodgates of the post-World War II period opened, extensive techniques were developed and utilized in power requirement studies. These studies embodied factors developed by basic and applied research in the field of rural electrification.[24] They included:

1. The level of farm incomes
2. Kind and size of specific farm enterprise
3. Length of time with electric service
4. Wholesale and retail rates
5. Competitive energy sources
6. Adequacy of electric service
7. Promotional efforts
8. New technological developments

The postwar period also had an old factor re-emphasized and firmed up, which is very important from the standpoint of design--the concept of "area coverage". It became a requirement that all loans be made with a written commitment that all consumers within the area for which the loan was being made would receive service. This meant that now a total area could be evaluated and an appropriate set of facilities designed. Estimates of load during this period, as used for design purposes, averaged 1800 to 3600 kwh per year. The difference in values reflected a variation in the ability of farm families in various sections of the United States to effectively utilize electric power. Design estimates during the postwar period were consumptions which were expected to be reached within 10 years. They usually ranged up to 200% of the consumption existing at the time of making the estimate.

Experience has shown repeatedly that in rural areas the consumption doubles every seven years. Today the average farm usage is 4500 kwh per year on these rural electric systems.

Each rural electric system is organized to serve a specific area. Usually this is one or more counties. The boundaries of each rural electric system are limited by adjoining rural electric systems or the area being served by adjoining commercial power companies. By Federal law, loans cannot be used for service in towns having a population in excess of 1500, or to provide service to consumers who are already receiving central station service.

During the past 6 years a concept of long-range engineering planning[25] has been developed and is now being applied to the design of rural electric systems.[26] Today, instead of building each facility for an estimated 10 years' growth, plans are developed for a system to handle 4-6 times present load. Supplementing this are annual work plans, based upon a current analysis of loads and system conditions.[27] This current analysis is used to determine the immediate construction required which is in accordance with the long-range objective or "target" system. In this way considerable long-range economy is effected.

B. Plans and Specifications

Plans and Specifications utilized in the construction of the rural electric system facilities are unique.

A consulting engineer, quite often the one who prepares the basic pattern for a system and handles the preparation of a loan application, designs the system as it is to be constructed. This design may cover one or several lines, substations and transmission facilities. The design and construction of generation facilities are usually handled separately. The supporting data for a design are discussed below. Once a design is decided upon, the engineer prepares the plans and specifications. These are usually set up on the basis of asking for competitive, sealed bids. All of the contractual terms, the conditions for preparation of bids, the standards for materials, the standards for physical construction and other related standards and specifications are all embodied in a prepared document which is available from the Rural Electrification Administration.[5,6,7,28] This document is adjusted, as appropriate, by the consulting engineer. The engineer estimates, on the basis of his previous experience and a limited amount of staking, the quantities of material required.

Instead of asking for bids for so many miles of line of a certain conductor size, the engineer estimates the number and kind of construction units required to build the line. This is the uniqueness of the plans and specifications. Each line consists of a group of assembly units; e.g., a pole is a unit; 1,000 feet of conductor is a unit; an anchor, a guy, a transformer, are all separate units. For the pole top configuration there is a separate unit for each particular standard pole top arrangement. In Figure 1, for example, a pole top unit would include the insulator pin, nut and bolt for the primary conductor and the bracket, bolt, nut, and washers for the neutral bracket. These quantities are inserted in the plans and specifications on sheets such as Figures 5, 6 and 7. The basic construction document for the distribution and transmission line construction is REA Form 830[18] plus one or several of the sets of standard drawings, REA Forms 803, 804 and 805.[5,6,7]

C. Supporting Data

The design of a system, a line, or a change in an existing system by a consulting engineer must be supported by sound engineering analyses. These include voltage regulation studies,[29] sectionalizing studies,[22] calculations and drawings for special structures, economic analyses for economical conductor selection[21] and any other special engineering studies as appropriate.

VIII

CONSTRUCTION

The techniques utilized in the construction phase of rural electric systems have been most significant in achieving low-cost, high-quality, facilities. These techniques apply to bidding procedures, construction methods, inspection requirements and production-line techniques. These apply principally to the construction of large mileages of line as occurred during the first 20 years of the rural electrification program.

A. Bidding

During the formative years of each electric system practically all construction contracts were awarded on competitive bidding. This condition was true for the first 20 years of the 25-year program. It proved to be the most economical method of construction. It is particularly adaptable to extensive construction programs.

Bidding is a process whereby the engineer prepares detailed plans and specifications as described above. These are then made available to contractors 30 to 60 days prior to a specified bid opening date. Each contractor looks over the area of proposed construction and prepares his bid. The bid consists of establishing his particular "bid" price for each individual assembly unit of construction; e.g., 35 foot, class 6 poles; 35 foot, class 7 poles; 1,000 feet of No. 2 7/1 ACSR conductor; 1,000 feet of No. 1/0-6/1 ACSR conductor; 3 kva transformers; 5 kva transformers; etc. These assembly unit prices are multiplied by the estimated number of units and the results totalled for each group of assembly units, as illustrated in Figures 5, 6 and 7. The sealed bids are opened by the engineer in the presence of all bidders and system management. The contract is awarded to the contractor having the lowest total bid.

B. Construction Methods

In addition to construction by a contractor as a result of competitive bidding, several other methods are presently used. These have certain value since practically all of the rural electric systems already have their base facilities constructed. These methods include construction by the systems' own forces, negotiating a substantial piece of construction with a private contractor, and neogtiating certain unit prices with a contractor for piecemeal construction of short extensions through a given period, for example, a year.

Another way of looking at the method of construction is from the standpoint of tools and equipment utilization. 25 years ago most of the work was accomplished by hand and with hand tools. An example was the digging of holes with post-hole diggers, shovels and spoons. The large scale construction occasioned by the rural electric systems prompted engineers, contractors and manufacturers to seek ways and means of expediting and economizing construction. This resulted in a number of developments. Among these were special rigs for stringing conductor under tension, for prestressing conductor and for mechanically digging pole holes.

C. Inspection

Stringent post-construction inspection by resident field engineers of the consulting engineer and by the REA were very essential. This inspection is predicated on the assumption that, unless facilities were constructed according to standards, according to the plans and specifications, and in a first-class workman-like manner, there was no assurance that the facilities would provide adequate service and protect the security of the loan. In some cases this inspection would be 100% of all facilities. In most cases it consisted of periodic inspection during construction with at least 10% or more detailed inspection on a selective basis upon completion of construction. A 10% final payment was withheld from the contractor pending this final inspection and his correcting all errors or other necessary changes found by the inspector.

These inspectors representing the consulting engineer and the Rural Electrification Administration also kept a close watch on the materials received for and used on the job. This was a precaution to assure that only materials which were acceptable for use on REA-financed facilities were used.[19]

D. Mass Construction

Even though large-scale standardized construction was undertaken in the development of the rural electric system, the cost still would not have been lowered if it had not been for the use of production-line techniques.[1] Combined, these permitted the construction of lines for $500 per mile during the period prior to World War II. This was a 50% reduction from other streamlined rural line construction without the benefit of these elements. Large-scale construction and standardized construction units, e.g., pole top configurations, permitted contractors to utilize a production-line construction technique. This was an innovation in the electric utility industry.

In applying this production-line technique to the building of rural electric facilities, a contractor would train crews of men for each of the individual operations required. Some of these operations were: the distribution of poles; the digging of pole holes; putting the hardware and other equipment on the pole before it was raised (this eliminated the costly practice of having a lineman climb the pole to install the hardware); setting the pole and backfilling the pole holes; stringing the conductor; pulling the conductor up to the proper tension and sag; installing the transformer at the farm; and installing the service to the farmhouse or barn. Each of these crews, specially trained and equipped, would move down the line one after the other, performing its function on a repetitive basis. In the period 1947-1951, a national construction average of 561 miles per working day was reached. The peak was 707 miles per day in 1949.

E. Piecemeal Construction

On the opposite end of the scale from mass construction with its application of the production-line technique, is the piecemeal construction of short line extensions. Here, to keep costs down, two methods are utilized. The first is to utilize the maintenance and operation crew for this limited construction work. This is accomplished by carefully integrating the new construction and the maintenance work. This provides for increased productivity of the regular crews as well as keeping them up to date as far as new construction practices are concerned.

A second method is to enter into an agreement with a contractor for the construction of short extensions. The contractor again works on the basis of increasing the productivity of a crew by "filling in" with this scattered small work, or he contracts with a number of systems for such work, which together permit economy.

DISTRIBUTION CONSTRUCTION UNITS

Section 1--POLE UNITS

Species of Timber: Southern Yellow Pine

Kind of Preservative (Creosote or Pentachlorophenol): Pentachlorophenol

Method of Treatment: (Check one)

1. Pressure: X

2. Nonpressure:

a. Butt: ________ b. Full Length: ________

(Engineer to complete above)

Unit No.	No. of Units	Unit Price			Extended Price--Labor and Materials
		Labor	Materials	Labor and Materials	
30-4	12	$12.50	$21.95	$34.45	413.40
30-5	15	12.50	18.00	30.50	457.50
30-7	10	12.50	12.95	25.45	254.50
35-4	87	13.00	29.50	42.50	3,697.50
35-5	94	13.00	26.15	39.15	3,680.10
35-6	1	13.00	20.00	33.00	33.00
35-7	19	13.00	17.50	30.50	579.50
40-3	27	14.00	42.00	56.00	1,512.00
40-4	39	14.00	37.50	51.50	2,008.50
40-5	23	14.00	32.00	46.00	1,058.00
40-6	3	14.00	27.00	41.00	123.00
45-3	4	16.00	49.50	65.50	262.00
45-4	19	16.00	43.50	59.50	1,130.50
45-5	14	16.00	33.75	54.75	766.50
45-6	5	16.00	33.00	49.00	245.00

Total, Section 1-- $16,221.00

FIG. 5

DISTRIBUTION CONSTRUCTION UNITS--(Continued)

Section A--SINGLE PHASE POLE TOP ASSEMBLY UNITS

Unit No.	No. of Units	Unit Price			Extended Price-Labor and Materials
		Labor	Materials	Labor and Materials	
A1	51	$ 2.00	$ 3.10	$ 5.10	260.10
A2	1	2.00	6.00	8.00	8.00
A4	1	3.00	20.00	23.00	23.00
A5	2	2.50	9.00	11.50	23.00
A5-1	2	2.50	12.25	14.75	29.50
A5-2	15	2.50	14.25	16.75	251.25
A5-3	4	2.50	11.25	13.75	55.00
A9	5	5.00	18.00	23.00	115.00
A9-1	2	4.00	8.50	12.50	25.00

Total, Section A--$789.85

FIG. 6

DISTRIBUTION CONSTRUCTION UNITS--(Continued)

Section D--CONDUCTOR ASSEMBLY UNITS

Unit No.	No. of Units	Unit Price			Extended Price-Labor and Materials
		Labor	Materials	Labor and Materials	
D*0 ACSR 6/1	158.0	$16.00	$50.00	$66.00	$10,428.00
D 2 ACSR 6/1	165.0	14.00	33.00	47.00	7,755.00
D 4 ACSR 7/1	81.0	13.00	23.50	36.50	2,956.50
D 8A CWC	1.0	12.00	10.00	22.00	22.00

*Manufacturer's designation

Total, Section D-- $21,161.50

FIG 7

IX

OPERATION and MAINTENANCE

The rural electric systems contain certain natural operating characteristics which are unique in that they apply to the entire system. These include long spans, high-strength conductor, extensive exposure to lightning, storms and trees, long transportation runs and inadequate rural communication systems. From the beginning, the rural electric systems have been faced with the need for giving operation and maintenance high priority attention. This starts with design. It has included the development of materials, standards of construction and operating practices. Illustrative aspects worth noting are sectionalizing, rights-of-way and brush control, communications, poles, equipment and materials performance, job training and operating problems.

A. Sectionalizing

It was learned early in the existence of the rural lines that fuses were unsatisfactory. The automatic circuit recloser was developed. This permitted a line to be automatically opened on intermittent fault and to lock out only after three previous efforts to reclose. The recloser is a self-triggered and resetting device which will carry full fault current. The design of the sectionalizing plan is an essential element of every annual work plan and engineer's new design plans.[22] This device alone has reduced overall construction as well as operating and maintenance costs.

B. Rights-of-Way

Most rural lines are built on private rights-of-way. For a single-phase 7200 volt line a right-of-way of 20 feet or more is required. Initially the rights-of-way were 10 feet. These proved inadequate. Extensive methods of utilizing mechanical and chemical means of controlling brush have been developed and are used. The best method is a combination of both best adapted to the location and its use on a regular schedule. Maintenance of ground cover for wild life, protection against erosion and maintenance of accessibility to service crews must all be assured.[30]

C. Communications

The great distances involved in operating a rural electric system necessitated the development and application of the mobile two-way radio system. This technique is now used universally. All service vehicles and many of the construction vehicles are equipped with two-way mobile radios. These communication systems are designed and installed so that communication can be had between vehicles on any part of a system. Now that rural telephony has increased the number of farms in rural areas having telephone service from 20% to 70%, system personnel receive early information of outages from consumers. This has facilitated service restoration and improved service continuity.

D. Poles

Wood Poles have been used universally. These poles are pressure-treated empty-cell with creosote or pentachlorophenol-petroleum. A thermal non-pressure treatment is used for some of the species in the northwest part of the United States. Pole dimensions are those established by the American Standards Association (ASA) through its Committee 05 on Wood Poles. These standard dimensions provide that poles of the same class, regardless of species and treatment, will have the same design load carrying ability.

Poles are the most vulnerable part of the electrical plant. Being a product of nature, subject to all the vagaries thereof, they decay despite treatment. The rural electric systems, after 25-years' experience and a weighted age of 12 years, are now giving poles increasing attention. Sampling inspection of poles is undertaken between the 8th and 10th years of service. More detailed samples are drawn and inspected around the 15th year of service. Thereafter all poles are inspected.[31]

E. Equipment and Materials Performance

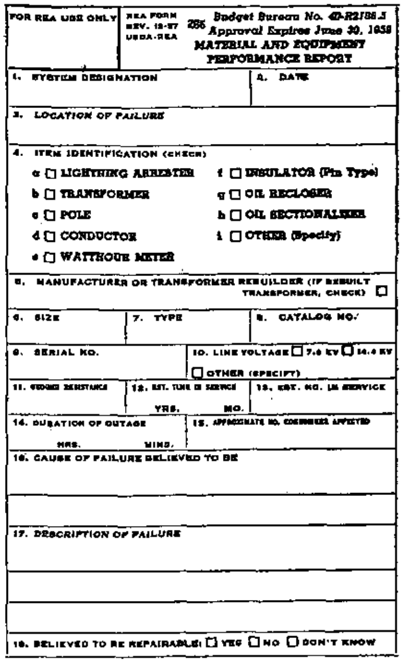
The Rural Electrification Administration has been undertaking, for the past ten years, a systematic analysis of equipment performance on the basis of reports submitted by the rural electric systems. These reports are submitted on a postal card form as shown in Figure 8. All items are reported upon by the statistically selected systems, which approximate 20% of all rural electric systems. All reports are reviewed with the principal attention being given to poles, transformers and conductors. The disclosures of these reports have resulted in remedial measures applicable to operation, maintenance and materials.

F. Job Training

The rural electric systems were basically a "boot-strap operation". The management, both the directors and the managers, had little or no electric system experience. Most of the crews were likewise inexperienced. The systems have grown rapidly as have the working forces. This required training. It required specific job training in how to perform various construction, operation and maintenance tasks. To accomplish this, the systems within each state organized a job training program. This program provided for the hiring of an itinerant instructor. The itinerant instructor visits each system once each quarter or more often. He holds a day-long training session with the crews both indoors and in the field. Between the instructor's visits, the foremen or line superintendent conduct training classes following the pattern of material left by the itinerant instructor. This has proved to be a most worthwhile and successful undertaking. It has reduced costs by improving efficiency and safe work.

G. Operating Problems

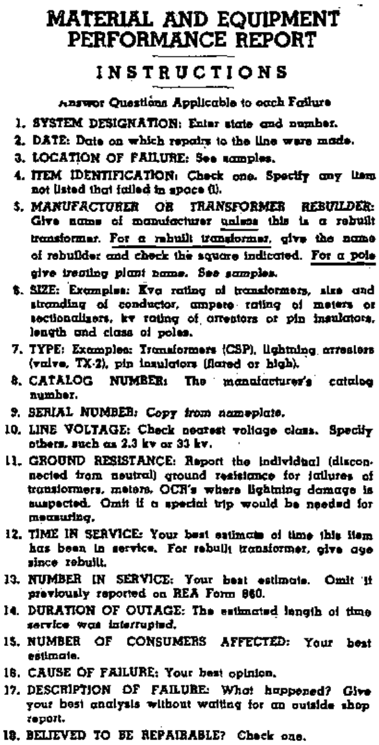
The operating problems which have developed on the rural electric systems have been numerous. Illustrative are inductive coordination anchor rod corrosion, primary overvoltages, radio and TV interference, conductor vibration, galloping conductor, transformer replacement, punctured insulators, woodpecker damage to poles, inadequate grounding and atmospheric corrosion. These individual problems will not be discussed here but each has provided an interesting and worthwhile source of experience and knowledge. Each has contributed its share to the more economical design, construction and operation of the rural electric systems. Some of these problems could have been anticipated but resulted from calculated risk or the lack of adequate experience. An example of this is the use of 9½ D and 3 No. 12 copperweld conductor. The estimated revenue for certain lines would not pay for greater investment and these conductors had the required physical and electrical capacity. However, in due course, owing to constant wind velocity in certain areas, these conductors have presented a very serious operating problem of aeolian vibration. Presently laboratory and field studies are resulting in the development of a simple inexpensive damper that can be utilized both on existing and new lines. Hence an operating problem is being turned into a benefit.



FOR REA USE ONLY
REA FORM 286
REV. 12-57
USDA-REA
Budget Bureau No. 40-R2188.5
Approval Expires June 30, 1959
MATERIAL AND EQUIPMENT
PERFORMANCE REPORT

1. SYSTEM DESIGNATION
2. DATE
3. LOCATION OF FAILURE
4. ITEM IDENTIFICATION (CHECK)
a ☐ LIGHTNING ARRESTER
b ☐ TRANSFORMER
c ☐ POLE
d ☐ CONDUCTOR
e ☐ WATTHOUR METER
f ☐ INSULATOR (Pin Type)
g ☐ OIL RECLOSER
h ☐ OIL SECTIONALIZER
i ☐ OTHER (Specify)
5. MANUFACTURER OR TRANSFORMER REBUILDER (IF REBUILT TRANSFORMER, CHECK) ☐
6. SIZE
7. TYPE
8. CATALOG NO.
9. SERIAL NO.
10. LINE VOLTAGE ☐ 7.2 KV ☐ 14.4 KV ☐ OTHER (SPECIFY)
11. GROUND RESISTANCE
12. EST. TIME IN SERVICE YRS. MO.
13. EST. NO. IN SERVICE
14. DURATION OF OUTAGE HRS. MINS.
15. APPROXIMATE NO. CONSUMERS AFFECTED
16. CAUSE OF FAILURE BELIEVED TO BE
17. DESCRIPTION OF FAILURE
18. BELIEVED TO BE REPAIRABLE: ☐ YES ☐ NO ☐ DON'T KNOW

a. REA Form 286



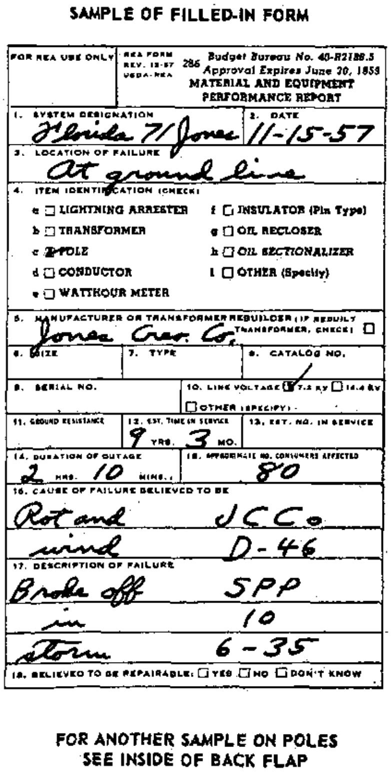
MATERIAL AND EQUIPMENT
PERFORMANCE REPORT

INSTRUCTIONS

Answer Questions Applicable to each Failure

1. SYSTEM DESIGNATION: Enter state and number.
2. DATE: Date on which repairs to the line were made.
3. LOCATION OF FAILURE: See samples.
4. ITEM IDENTIFICATION: Check one. Specify any item not listed that failed in space (i).
5. *MANUFACTURER OR TRANSFORMER REBUILDER:* Give name of manufacturer unless this is a rebuilt transformer. For a rebuilt transformer, give the name of rebuilder and check the square indicated. For a pole give treating plant name. See samples.
6. SIZE: Examples: Kva rating of transformers, size and stranding of conductor, ampere rating of meters or sectionalizers, kv rating of arrestors or pin insulators, length and class of poles.
7. TYPE: Examples: Transformers (CSP), lightning arresters (valve, TX-2), pin insulators (flared or high).
8. CATALOG NUMBER: The manufacturer's catalog number.
9. SERIAL NUMBER: *Copy from nameplate.*
10. LINE VOLTAGE: Check nearest voltage class. Specify others, such as 2.3 kv or 33 kv.
11. GROUND RESISTANCE: Report the individual (disconnected from neutral) ground resistance for failures of transformers, meters, OCR's where lightning damage is suspected. Omit if a special trip would be needed for measuring.
12. TIME IN SERVICE: Your best estimate of time this item has been in service. For rebuilt transformer, give age since rebuilt.
13. NUMBER IN SERVICE: Your best estimate. Omit if previously reported on REA Form 860.
14. DURATION OF OUTAGE: The estimated length of time service was *interrupted.*
15. NUMBER OF CONSUMERS AFFECTED: Your best estimate.
16. CAUSE OF FAILURE: Your best opinion.
17. DESCRIPTION OF FAILURE: What happened? Give your best analysis without waiting for an outside shop report.
18. BELIEVED TO BE REPAIRABLE? Check one.

b. Instructions (front cover) with each book of forms



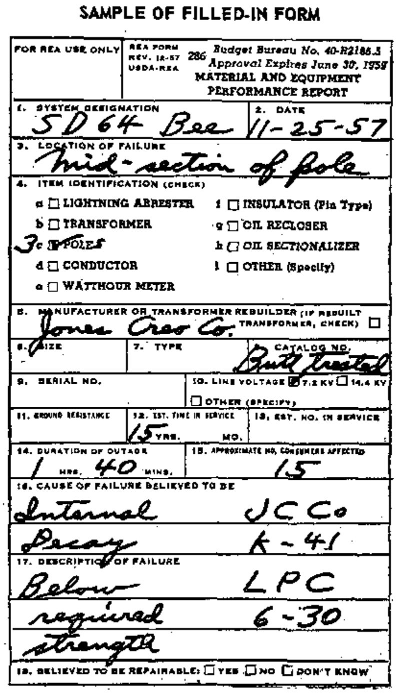
SAMPLE OF FILLED-IN FORM

FOR REA USE ONLY
REA FORM 286
REV. 12-57
USDA-REA
Budget Bureau No. 40-R2188.5
Approval Expires June 30, 1959
MATERIAL AND EQUIPMENT
PERFORMANCE REPORT

1. SYSTEM DESIGNATION Florida 7/Jones
2. DATE 11-15-57
3. LOCATION OF FAILURE At ground line
4. ITEM IDENTIFICATION (CHECK)
a ☐ LIGHTNING ARRESTER
b ☐ TRANSFORMER
c ☒ POLE
d ☐ CONDUCTOR
e ☐ WATTHOUR METER
f ☐ INSULATOR (Pin Type)
g ☐ OIL RECLOSER
h ☐ OIL SECTIONALIZER
i ☐ OTHER (Specify)
5. MANUFACTURER OR TRANSFORMER REBUILDER (IF REBUILT TRANSFORMER, CHECK) ☐ Jones Creo. Co.
6. SIZE
7. TYPE
8. CATALOG NO.
9. SERIAL NO.
10. LINE VOLTAGE ☒ 7.2 KV ☐ 14.4 KV ☐ OTHER (SPECIFY)
11. GROUND RESISTANCE
12. EST. TIME IN SERVICE 9 YRS. 3 MO.
13. EST. NO. IN SERVICE
14. DURATION OF OUTAGE 2 HRS. 10 MINS.
15. APPROXIMATE NO. CONSUMERS AFFECTED 80
16. CAUSE OF FAILURE BELIEVED TO BE
Rot and JCCo
wind D-46
17. DESCRIPTION OF FAILURE
Broke off SPP
in 10
storm 6-35
18. BELIEVED TO BE REPAIRABLE: ☐ YES ☐ NO ☐ DON'T KNOW

FOR ANOTHER SAMPLE ON POLES
SEE INSIDE OF BACK FLAP

c. Inside front cover



SAMPLE OF FILLED-IN FORM

FOR REA USE ONLY
REA FORM 286
REV. 12-57
USDA-REA
Budget Bureau No. 40-R2188.5
Approval Expires June 30, 1959
MATERIAL AND EQUIPMENT
PERFORMANCE REPORT

1. SYSTEM DESIGNATION SD 64 Bee
2. DATE 11-25-57
3. LOCATION OF FAILURE Mid-section of pole
4. ITEM IDENTIFICATION (CHECK)
a ☐ LIGHTNING ARRESTER
b ☐ TRANSFORMER
3 c ☒ POLES
d ☐ CONDUCTOR
e ☐ WATTHOUR METER
f ☐ INSULATOR (Pin Type)
g ☐ OIL RECLOSER
h ☐ OIL SECTIONALIZER
i ☐ OTHER (Specify)
5. MANUFACTURER OR TRANSFORMER REBUILDER (IF REBUILT TRANSFORMER, CHECK) ☐ Jones Creo Co.
6. SIZE
7. TYPE
8. CATALOG NO. Butt treated
9. SERIAL NO.
10. LINE VOLTAGE ☒ 7.2 KV ☐ 14.4 KV ☐ OTHER (SPECIFY)
11. GROUND RESISTANCE
12. EST. TIME IN SERVICE 15 YRS. MO.
13. EST. NO. IN SERVICE
14. DURATION OF OUTAGE 1 HRS. 40 MINS.
15. APPROXIMATE NO. CONSUMERS AFFECTED 15
16. CAUSE OF FAILURE BELIEVED TO BE
Internal JCCo
Decay K-41
17. DESCRIPTION OF FAILURE
Below LPC
required 6-30
strength
18. BELIEVED TO BE REPAIRABLE: ☐ YES ☐ NO ☐ DON'T KNOW

d. Inside of back cover

REA Form 286 - Reporting Form and Instructions
Pole Performance Study - 1959

X

PLANNING

The key characteristic of the development of rural electric systems in the United States has been "planning", since the inception of the rural electric system and the development of extensive construction in 1935. Facilities have been built for load growth. There have been some variations in the rate and magnitude of the growth, but in the early years a target load of 10 years in the future became commonplace. Today long-range planning for four to six times present load is common. [25]

A. Long-Range Engineering Planning

The consulting engineer for each system develops and submits to the management a long-range engineering plan for the rural electric system.[26] If approved, he then keeps it current. This plan is based upon four to six times load at any time of consideration. It does not detail every line extension. It provides the framework of a system to handle the design loads. If there are two or more logical methods of doing this, these alternatives are outlined. This is a plan. It is a set of target conditions or objectives. It is not a design for construction. It is a base, however, for estimating probable financial requirements, power supply, rights-of-way, substation locations and other important elements of the future rural electric system. It is the pattern against which all current decisions for construction and financing are compared. As conditions change from year to year, the long-range engineering plan is reviewed and revised accordingly. It is constantly kept current as the objective.

B. Long-Range Financial Forecasts

The long-range financial forecasts are those prepared by the management of the system for its own guidance and decision-making actions.[32] Generally it goes at least ten years into the future on a detailed annual basis. For construction requirements it utilizes the data from the long-range engineering plan.[26] For operation and maintenance requirements, it utilizes comprehensive periodic surveys of the electrical and physical facilities.[33] For future growth it utilizes power requirement studies and other economic evaluations of the service area.[34] The data embodied in the long-range financial forecast assists REA in its feasibility studies for individual loan applications. The forecast also permits the management of the system to know the extent to which reserves are needed and the extent to which its own funds can be reinvested in plant.

C. Load Estimating

The estimating of loads for loan feasibility purposes is an inherent responsibility of REA. However, it is also an inherent responsibility of the rural electric system to know its own future energy consumption. Thus the system should analyze and develop estimates on its own.[34] Through this it is able to agree or disagree with REA's estimate and to fit the necessary consumption data into its long-range financial forecast. The factors utilized in arriving at these estimates are those cited previously. The rural electric systems can, and many do, estimate their loads as far as 15, 20 or 25 years into the future.

D. Annual Work Plans

The annual work plan is a determination by each individual system, on the basis of a current evaluation of load, physical and electrical facilities and service reliability studies, of construction outlined in the long-range engineering plan that must be completed during the next year or two.[27] It is a detailed construction plan. It provides for all construction, however small or large. It is the basis for issuing work orders for construction by the system's own crews or for preparation of plans and specifications for bidding, with construction by a contractor. It is also the basis for the committing of funds from general reserved or the requesting of a new loan from REA.

E. Annual Budget

The annual budget is a determination by the rural electric system of the cash requirements for all purposes during the ensuing twelve months.[35] It is determined by the prior analysis and decisions involved in the annual work plan.

XI

SUMMARY

The rural electric system is an electric distribution system, 7.2/12.5 kv, serving rural areas generally through a cooperative organization on an independent self-sustaining basis. Capital is secured from Federal Government long-term loans, which are amortized over a 35-year period, and from current revenue general funds.

Construction costs have been held at the lowest possible level, consistent with the assurance of necessary quality construction, through effective cooperation of system management, engineers, contractors, manufacturers and REA. Standards of materials, construction units, procedures, engineering techniques, inspection and planning have been an integral part. Uniform listing of materials, large-scale construction, application of production-line techniques to construction and engineering guidelines from REA were all important contributors to the economical and effective results.

Operation and maintenance of long span, high-strength conductor, vertical construction facilities serving about three consumers per mile throughout vast rural areas is a major consideration for system management. The complete dependence of the consumers on these rural electric systems upon continuity of reliable and adequate electric service emphasizes the role and responsibility of operating management. Service comparable to that in the cities is the objective.

BIBLIOGRAPHY

Reference Number	Title
1	The Yearbook of Agriculture, 1960 - Power to Produce, Pages 69, 75, 455
2	REA Bulletin 1-1, 1959 - REA Annual Statistical Report - Rural Electrification Borrowers
3	Characteristics and Technical Problems of the Rural Distribution Systems in the United States - Robert D. Partridge and John H. Rixse, Jr., Paper #26, Section B.4, XIth Sectional Meeting, World Power Conference, Belgrade, Yugoslavia, 1957
4	Report of the Administrator of the Rural Electrification Administration, 1960
5	REA Form 804 - Description of Units, Specifications, and Drawings for 7.2/12.5 KV Line Construction
6	REA Form 803 - Description of Units, Specifications, and Drawings for 14.4/24.9 KV Line Construction
7	REA Form 805 - Description of Units, Specifications, and Drawings for Transmission Voltage Line Construction
8	National Electrical Safety Code (Grounding Rules and Parts I, II, III, IV and V) - March 1948 - National Bureau of Standards Handbook H30 - Approved by American Standards Association
9	Installation and Maintenance of Electric Supply and Communication Lines, Safety Rules and Discussion (Comprising Part 2, the Discussion of Part II, the Definitions, and the Grounding Rules of the Fifth Edition of the National Electrical Safety Code) August 1949 - National Bureau of Standards Handbook H43
10	REA Bulletin 7-1R1, May 1954 - Guiding Statement of REA Policy Concerning Its Relationship with Borrowers
11	REA Bulletin 1-3, June 1957 - Rural Electrification Act of 1936 with Amendments as Approved to June 1957
12	REA Bulletin 20-2, November 1959 - Electric Loan Policy and Application for Section 4 Loans
13	REA Bulletin 20-6, January 1959, Loans for Generation and Transmission

14 REA Bulletin 24-1, September 1957, Consumers Equipment and Installation Loans under Section 5 of the Rural Electrification Act

15 REA Bulletin 41-1, October 1958, Engineering Services for Electric Borrowers

16 REA Bulletin 40-6, November 1959, Construction Methods and the Purchase of Materials and Equipment

17 REA Bulletin 111-2, June 1959, Annual Report of Energy Purchased by REA Borrowers

18 REA Bulletin 44-1, January 1947, Specifications and Standards for Materials and Equipment

19 REA Bulletin 43-5. June 1960, List of Materials Acceptable for Use on Systems of REA Electrification Borrowers

20 REA Bulletin 169-4, March 1952, Voltage Levels on Rural Distribution Systems

21 REA Bulletin 60-9, May 1960, Economical Design of Primary Lines for Rural Distribution Systems

22 REA Bulletin 61-2, March 1958 (and supplement, October 1958), Guide for Making a Sectionalizing Study on Rural Electric Systems

23 REA Bulletin 60-7, June 1960, Service Reliability

24 American Institute of Electrical Engineers (AIEE) Conference Paper 60-5003, May 1960, Everett R. Brown, Forecasting Power Requirements for Rural Distribution Systems

25 American Institute of Electrical Engineers (AIEE) Transactions Paper 55-746, October 1955, John H. Rixse, Jr., Rural Electric System Planning

26 REA Bulletin 60-8, June 1957, System Planning Guide for Electric Distribution Systems

27 REA Bulletin 60-10, November 1959, Annual Work Plans, Electric Distribution Systems

28 REA Form 830, April 1955, Electric System Construction Contract (Labor and Material)

29 REA Bulletin 45-1, February 1953, Procedure for Making Voltage Drop Study

30 REA Bulletin 161-17, April 1959, Brush Control Practices for Right-of-Way Control

31 REA Bulletin 161-4, July 1957, Pole Maintenance

32 REA Bulletin 105-4, May 1960, Financial Planning for Business Security

33 REA Bulletin 161-5R1, March 1954, Review of Systems and Facilities of Electrification Borrowers as Related to System Operation and Maintenance

34 REA Bulletin 120-1, August 1960, Estimate of KWH Consumption and Power Requirements

35 REA Bulletin 105-1, September 1958, Annual Budgeting for Electric Distribution Borrowers