

IEEE Guide to the Assembly and Erection of Concrete Pole Structures

Sponsor

**Transmission and Distribution Committee
of the
IEEE Power Engineering Society**

Approved September 15, 1993

Reaffirmed March 31, 2011

IEEE Standards Board

Approved February 24, 1994

Reaffirmed April 16, 2012

American National Standards Institute

Abstract: Good practice that will improve the ability to assemble and erect self-supporting and guyed concrete pole structures for overhead transmission lines is presented. Construction aspects after foundation installation and up to the conductor stringing operation are covered. Some aspects of construction related to other materials use in concrete pole structures are covered, but the treatment is not complete. The guide is intended to be used as a reference source for parties involved in the ownership, design, and construction of transmission structures.

Keywords: assembly and erection, concrete pole structures, transmission structures

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

Copyright © 1993 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 1993. Printed in the United States of America

ISBN 1-55937-367-9

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Notice and Disclaimer of Liability Concerning the Use of IEEE Documents: IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon any IEEE Standard document.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained in its standards is free from patent infringement. IEEE Standards documents are supplied "AS IS."

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

Translations: The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official Statements: A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on Standards: Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important to ensure that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. Any person who would like to participate in evaluating comments or revisions to an IEEE standard is welcome to join the relevant IEEE working group at <http://standards.ieee.org/develop/wg/>.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854
USA

Photocopies: Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

(This introduction is not a part of IEEE Std 1025-1993, IEEE Guide to the Assembly and Erection of Concrete Pole Structures.)

This guide, covering all aspects of overhead transmission line construction, is one of several that are being prepared by the Working Group on Construction of Overhead Lines. This particular guide presents construction considerations for material delivery, assembly and erection of concrete pole structures, and installation of insulators and hardware. This guide is intended to be used as a reference source for parties involved in the ownership, design, and construction of transmission structures.

At the time this guide was completed, the Working Group on Construction of Overhead Lines had the following membership:

D. C. Sherman, *Chair*[†]

R. L. Donelson[†]
T. E. Rodgers[†]

D. Hamilton

Dennis Mize
G. J. Ruschkofski

[†]Voting member at the time of publication

The following persons were on the balloting committee:

R. H. Arndt
James J. Burke
Vernon L. Chartier
W. H. Cole
Glenn A. Davidson
Dale Douglass
Donald A. Gillies
E. J. Goodwin

I. S. Grant
Jerome G. Hanson
J. G. Kappenman
George Karady
Nestor Kolcio
H. Lam
Keith E. Lindsey
J. H. Mallory
Thomas J. McDermott

Franklin D. Myers
Stig L. Nilsson
R. G. Oswald
R. L. Patterson
P. D. Quinn
W. Edward Reid
B. R. Shperling
J. M. Van Name, Jr.

When the IEEE Standards Board approved this guide on September 15, 1993, it had the following membership:

Wallace S. Read, *Chair*

Donald C. Loughry, *Vice Chair*

Andrew G. Salem, *Secretary*

Gilles A. Baril
José A. Berrios de la Paz
Clyde R. Camp
Donald C. Fleckenstein
Jay Forster*
David F. Franklin
Ramiro Garcia
Donald N. Heirman

Jim Isaak
Ben C. Johnson
Walter J. Karplus
Lorraine C. Kevra
E. G. "Al" Kiener
Ivor N. Knight
Joseph L. Koepfinger*
D. N. "Jim" Logothetis

Don T. Michael*
Marco W. Migliaro
L. John Rankine
Arthur K. Reilly
Ronald H. Reimer
Gary S. Robinson
Leonard L. Tripp
Donald W. Zipse

*Member Emeritus

Also included are the following nonvoting IEEE Standards Board liaisons:

Satish K. Aggarwal
James Beall
Richard B. Engelman
David E. Soffrin
Stanley I. Warshaw

Valerie E. Zelenty
IEEE Standards Project Editor

Contents

CLAUSE	PAGE
1. Overview.....	1
1.1 Scope.....	1
1.2 Purpose.....	1
1.3 Application.....	1
1.4 Safety	1
1.5 Legal disclaimer.....	2
2. References.....	2
3. Definitions	2
4. Structural design considerations	3
4.1 Construction and maintenance loads	3
4.2 Material delivery	4
4.3 Constructability of concrete pole structures	5
4.4 Helicopter construction.....	7
5. Material delivery.....	7
5.1 Material yard.....	7
5.2 Receipt and inspection of material.....	8
5.3 Handling and storage of material.....	9
5.4 Overages, shortages, and replacement material.....	10
5.5 Surplus material	10
6. Assembly and erection of concrete pole structures	10
6.1 Handling and transportation of poles, arms, and component parts.....	12
6.2 Single pole structures.....	12
6.3 Framed structures.....	18
6.4 Helicopter erection.....	20
6.5 Attaching pole structures to various foundations	21
6.6 Post-erection	24
7. Assembly and installation of insulators and hardware	25
7.1 Assembly of insulators and hardware.....	25
7.2 Installation of cotter keys.....	26
7.3 Installation of assemblies.....	26
8. Quality assurance	27
9. Bibliography	28

IEEE Guide to the Assembly and Erection of Concrete Pole Structures

1. Overview

1.1 Scope

This guide presents various approaches of good practice that will improve the ability to assemble and erect self-supporting and guyed concrete pole structures. This guide covers construction aspects after foundation installation and up to the conductor stringing operation.

Concrete pole structures may have components made of other materials (i.e., steel, wood, aluminum). Though some aspects of construction related to these materials are covered in this document, it should not be considered complete. Other documents cover these materials in more detail (see IEEE Std 951-1988¹).

1.2 Purpose

The purpose of this guide is to present the construction considerations for material delivery, assembly and erection of structures, and installation of insulators and hardware.

1.3 Application

This guide is intended to be used as a reference source for parties involved in the ownership, design, and construction of transmission structures. Since methods will be strongly influenced by the nature of each project, various methods that have been successfully employed are presented.

If any recommendations contained within this guide are to be adopted, they should be specifically stated in the owner's design and construction specifications. Any legal requirements of national, state, provincial, or local regulations must, of course, be observed.

1.4 Safety

Handling, assembly, and erection of concrete pole structures requires conducting a safety and health program which takes all reasonable precautions to protect the safety and health of workers and members of the public and to prevent damage to public and private property. Workers must not be allowed to work in sur-

¹Information on references can be found in clause 2.

roundings or under working conditions which are unsanitary, hazardous, or dangerous to their health or safety. In the United States, compliance is required with the latest effective standards promulgated by the Secretary of Labor for the Department of Labor, Occupational Safety and Health Administration, Safety and Health Standards (29 CFR 1910), and the Construction Safety and Health Regulations promulgated under Section 107 of the Contract Work Hours and Safety Standards Act (29 CFR 1926) [B10].²

1.5 Legal disclaimer

The support data for this guide were collected from a great number of sources and are believed to be reliable and true. Care has been taken during the compilation and writing to prevent error or misrepresentations. The authors make no warranty with respect to the accuracy, completeness, or usefulness of the information contained in the guide, nor assume any liabilities with respect to the applicability or use of any information, method, or process presented in this publication.

2. References

This guide shall be used in conjunction with the following standards. When the following standards are superseded by an approved revision, the revision shall apply.

ASTM A780-90, Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.³

IEC 826-1991, Loading and Strength of Overhead Transmission Lines.⁴

IEEE Std 524-1991, IEEE Guide to the Installation of Overhead Transmission Line Conductors (ANSI).⁵

IEEE Std 951-1988, IEEE Guide to the Assembly and Erection of Metal Transmission Structures (ANSI).

3. Definitions

3.1 concrete pole structures: Structures consisting of one or more concrete poles. Other members of the structure may be reinforced concrete or other materials (i.e., wood, steel, aluminum). These structures are prefabricated, as opposed to being cast-in-place. Concrete pole structures may be manufactured in a variety of ways. A few examples are listed below:

- a) Hollow or solid members
- b) Different cross-sectional shape (i.e., round or square)
- c) Spun or statically cast (see figure 1)
- d) Pretensioned, posttensioned, or nontensioned reinforcing steel
- e) Single-piece or multipiece poles

²The numbers in brackets correspond to those in the bibliography in clause 9.

³ASTM publications are available from the Customer Service Department, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, USA.

⁴IEC publications are available from IEC Sales Department, Case Postale 131, 3 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

⁵IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

Combinations of the above may be used to achieve the desired results (see figure 1).

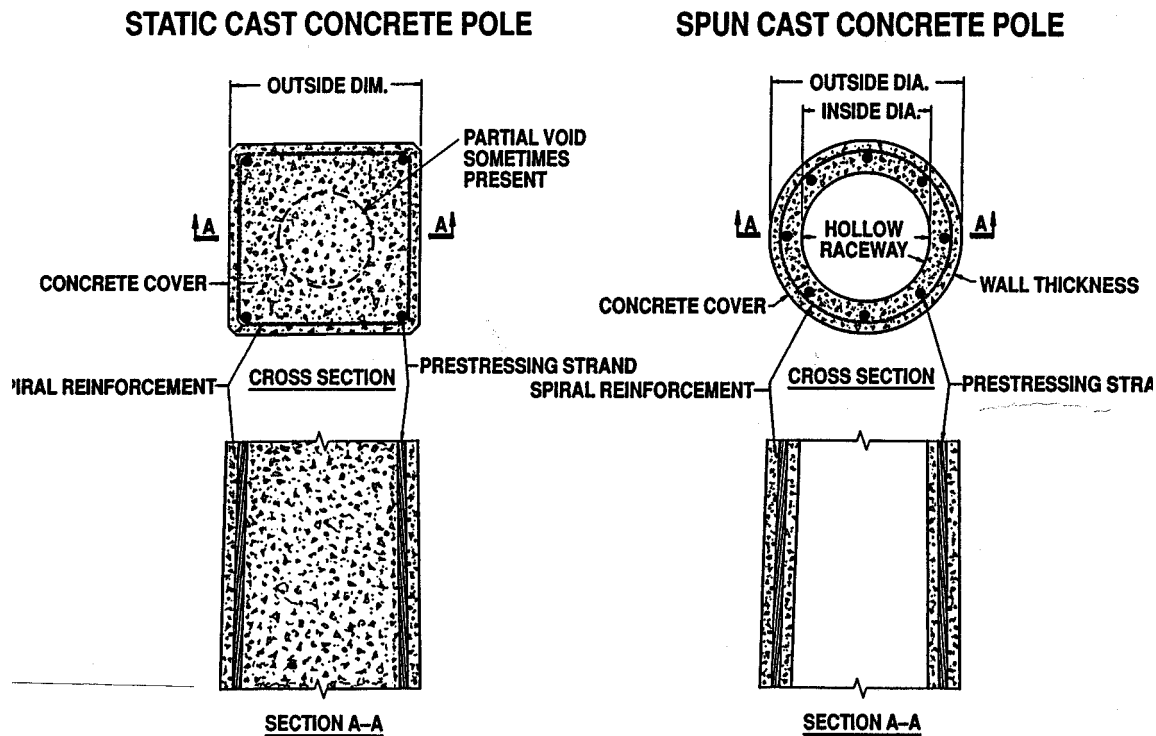


Figure 1—Various concrete pole sections

3.2 constructor: A party who undertakes the assembly and erection of a transmission structure for an owner, or an owner who undertakes all or part of a project alone. Synonymous with contractor, installer, construction agency, or construction department.

3.3 line designer: A party who develops structure-loading criteria, structure types, and structure locations based on line routing, maintenance, and construction requirements. The line designer should establish design criteria for construction and maintenance that will affect the structure designer and constructor. The line designer could be an owner or an agent acting for the owner.

3.4 owner: A party who owns the transmission line during the construction phase of the line and may include a person who acts for, or on behalf of, an owner as the owner's agent or delegate.

3.5 structure designer: A party who designs the structure based on criteria given by a line designer. The structure designer could be an owner, an agent acting for the owner, or a manufacturer.

4. Structural design considerations

4.1 Construction and maintenance loads

The line designer should review and define acceptable methods of construction and maintenance. Consideration should be given to the structure types, site conditions, applicable equipment, and worker skills. Structural or other details that relate to the safety of construction and maintenance work should be considered in the design of the structure. At the time of line design, the constructor may not have been selected. However,

the line designer should consult with knowledgeable constructors and maintenance personnel and utilize their experience to develop a reasonable balance between construction flexibility and efficiency vs. cost.

The line designer should specify the maximum anticipated loads that may be applied during construction and maintenance of the line, as well as the location of these loads (see IEEE Std 524-1991). Some of these loading considerations are as follows:

- a) Fully or partially assembled structures should be subjected to dead-weight loads, temporary guying loads for stability, worker loads, wind loads, and rigging loads during assembly and erection. Reasonable combinations of these loads should be anticipated by the designer and discussed with potential constructors to ensure safety and efficiency and prevent structural damage.
- b) Members on which a worker is expected to climb or stand should be designed to carry a load at midspan. This load should include the weight of the worker, the equipment, a safety factor, and possible dynamic loads (see IEEE Std 524-1991). Some construction or maintenance methods may require more than one worker to stand on a particular member.
- c) Portions of a structure may be subjected to additional loads due to one or more workers during construction and maintenance (e.g., the end of a cross arm). These loads, in addition to the normal wire loads anticipated during construction and maintenance, should be considered.
- d) If fall-prevention systems are required by the owner, additional facilities should be provided for safety equipment.
- e) Rigging attachment points should be provided for lifting the structure, hoisting insulators and travelers, stringing, clipping in, dead ending, and maintenance. All of these points should be explicitly identified. A diagram giving the allowable construction loads on the erected structure should be prepared and provided to the constructor.

Particular attention should be given to the following loading conditions:

- 1) Rigging methods used in hoisting may multiply the load at the attachment point [B11].
- 2) At the beginning and end of each conductor stringing operation, the conductors may be brought down to stringing equipment, anchors, or both. The vertical and horizontal components of tension imposed on the structure may become significant at these locations, and failures have occurred on both suspension and dead-end structures. The positioning of the stringing equipment or anchors is critical, especially in mountainous terrain (see IEEE Std 524-1991 and figure 2).
- 3) Various dead-ending techniques will apply different loads. For example, aerial dead-ending techniques may impose lower vertical loads than dead ending on the ground. Temporary back guying may be required depending on the longitudinal strength and flexibility of the dead-end structure and dead-ending technique used.

In addition, short spans between dead ends with high conductor tensions may result in loads in excess of maximum design tensions when the conductor is overpulled during the dead-ending operation.

4.2 Material delivery

The design of the structures should consider limits to the length, size, and weight of individual members due to shipping, handling, erection, terrain, and equipment restrictions (see 5.3).



Figure 2—Conductor stringing

4.3 Constructability of concrete pole structures

Construction can be enhanced by a number of considerations, both in the design of the structure and in the detailing of the connections. Some special considerations arise due to the large size and weight of the components being assembled.

It should be noted that these considerations could increase material costs, although these costs may be offset by reduced field costs and improved safety.

- a) Clearly and permanently mark (i.e., stamp) each member. This mark should be legible after any coatings are applied to facilitate identification and possible field replacement. These permanent markings should be visible after the structure is erected. Additional stencilling with waterproof paint will further facilitate field identification; however, care should be taken to avoid adverse visual impact (i.e., any additional stencil should be on the embedded portion of the pole).

Identification marks may include the following information:

- 1) Structure type
 - 2) Structure height
 - 3) Structure weight
 - 4) Structure manufacturer
 - 5) Date of manufacture
 - 6) Groundline moment capacity
- b) Design the structure with a minimal assortment of bolt diameters, types, and lengths.
 - c) Provide adequate clearance around nuts and bolt heads for wrenches or sockets.
 - d) For safety and ease of erection, provide a place for a worker to stand below a pole splice. As an example, two step bolt holes could be provided 1.37 m (4 ft 6 in) below each splice for optional step bolts.
 - e) Ensure that the Bill of Materials provides the product finish (i.e., galvanized or painted for metal members and treated for wood). The Bill of Materials should also provide the approximate weight of each item (i.e., members, plates, fills, bolts, and nuts) in order to determine the loads to be lifted.

- f) Provide legible erection drawings. The drawings should show the member mark identification, bolt size and length, bolt pattern, orientation of members, and whether a member is inside or outside its connecting member (i.e., use hidden lines and detailed or enlarged views). In addition, these erection drawings should show the rigging attachment points identified in 4.1, item e).
- g) Fabrication tolerances that are either too restrictive or too liberal can result in increased field costs (see IEEE Std 524-1991).
- h) Consideration should be given to the method of locking fasteners. The method selected will influence construction efficiency. Typical methods and devices are lock nuts, lock washers, punched threads, etc.
- i) Avoid connections where workers have to insert their hands between large members during assembly. For example, avoid joint designs that require insertion of tools or hands into the joint area during assembly.
- j) The pole supplier should include provisions for pick points and cant holes to minimize damage to the finish of the pole during the handling and erection process. Position of the lifting eyes or pick points should take into account construction methods, equipment, and site restrictions (see figure 3).

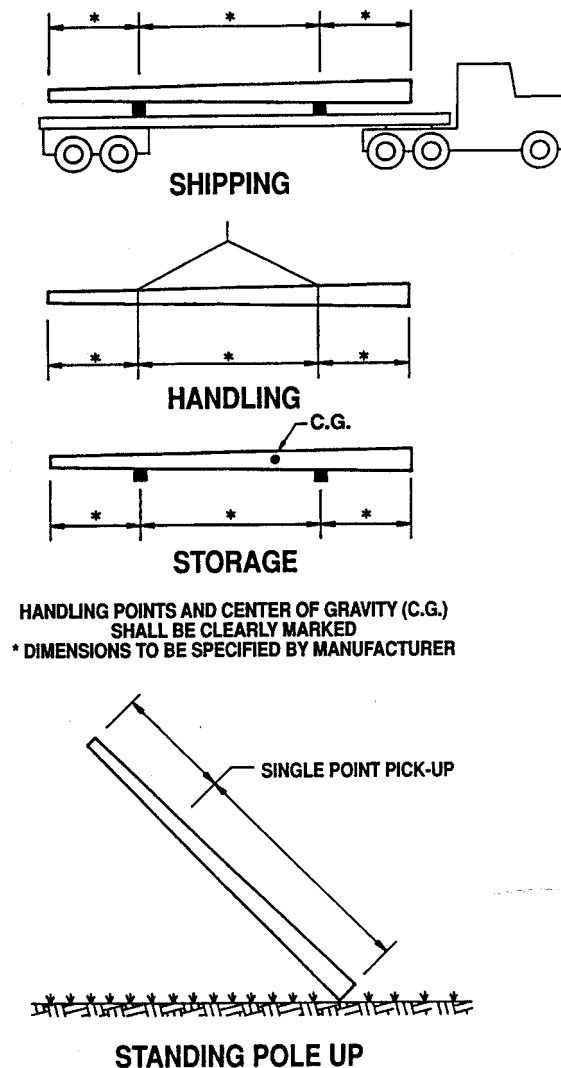


Figure 3—Concrete pole support points