

An American National Standard

IEEE Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in the Petroleum and Chemical Industry

Sponsor
**Petroleum and Chemical Industry Committee
of the
Industry Applications Society**

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Foreword

(This Foreword is not a part of ANSI/IEEE Std 576-1989, IEEE Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in the Petroleum and Chemical Industry.)

This document has been generated to provide guidance for installation of electrical cable systems within the Petroleum and Chemical Industry.

It has long been recognized that the majority of cable failures are a result of mechanical damage during installation. The use of this document should reduce the possibility of electrical failure in a cable system.

There are many specific details involved in the installation of cable systems that are subject to differences of opinion. This document covers only the major problem areas.

This document will be revised from time to time to incorporate the latest information available.

This document was prepared by the Cable Installation Working Group of the Petroleum and Chemical Industry Committee of the Industry Applications Society of IEEE, which consisted of the following members:

H. R. Stewart, Jr., *Chair*

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Jim Hunt
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Layton Tuggle

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1. General Provisions

1.1 Scope

This recommended practice provides a guide to installation, splicing, termination, and field-proof testing of cable systems for the petrochemical industry. It is not intended to be a design document, although many of the problems of installation can be avoided by designing cable layouts with the installation limits of this recommended practice.

1.2 Purpose

The purpose of this recommended practice is to provide a uniform guide of installation limits that will avoid premature cable failure due to improper installation and mechanical damage during installation. It is intended to provide a reference that can be specified for cable installations.

1.3 References

The following publications shall be used in conjunction with this standard:

[1] ANSI/IEEE Std 404-1986, IEEE Standard for Cable Joints for Use with Extruded Dielectric Cable Rated 5000 V Through 46 000 V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500 Through 500 000 V.¹

[2] Engineering Data, Copper and Aluminum Conductor Electrical Cables. Ramsey, NJ: The Okonite Company.

[3] IEEE Std 400-1980, IEEE Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.²

[4] Installation Practices for Cable Raceway Systems. Ramsey, NJ: The Okonite Company.

[5] ANSI/NFPA 70, National Electrical Code. Batterymarch Park, Quincy, MA: National Fire Protection Association, 1986.³

¹ANSI/IEEE publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from the Service Center, The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

²IEEE publications can be obtained from the Service Center, The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

2. Definitions

sidewall pressure: The pressure exerted on an insulated cable as the result of the cable's being pulled around a bend during installation.

occupancy factor: The factor by which the forces are adjusted due to cable spacing in a conduit. Sometimes called weight correction factor.

jamming: The wedging of cables in a conduit when three cables lie side by side in a flat plane.

minimum bending radius: The minimum radius that an insulated cable can be bent that will not cause mechanical damage during installation.

electrical connection: The point at which two or more electrical conductors are joined together to establish electrical continuity.

3. Pulling Tensions

3.1 Maximum Pulling Tension on Cable

3.1.1 Pulling Eye Attachment

With pulling eye attached to copper conductors, the maximum pulling strain should not exceed 0.008 times circular-mil area (CM). With pulling eye attached to aluminum conductors, the maximum pulling strain should not exceed 0.006 times circular-mil area (CM).

$$Tm = 0.008 \times n \times CM$$

Tm = Maximum tension, lbs
 n = number of conductors
 CM = circular mil area of each conductor

Maximum limitation for this calculation is 5000 lb for single conductor (1/C) cables and 6000 lb for multiple conductor cables.

3.1.2 Cable Grip Over Lead Sheath

With cable grip over lead sheath, the maximum pulling strain should not exceed 1500 lbs/sq in of lead sheath cross-sectional area for commercial lead.

$$Tm = \text{maximum tension (lbs)} = 4712t(D - t)$$

t = sheath thickness (in)
 D = overall diameter of cable (in)

3.1.3 Cable Grip Over Non-Leaded Cable

With cable grip over non-leaded cable, the maximum pulling strain should not exceed 1000 lbs and may not exceed the maximum tension based on 0.008 or 0.006 $\times$ total conductor area.

³ANSI/NFPA publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

3.2 Maximum Permissible Pulling Length for One Straight Section

$$L_m = \frac{T_m}{fW} \quad (1)$$

where

L_m = pulling length, (ft) [straight section]
 T_m = maximum tension (lbs)
 W = weight of cable per foot (lbs)
 f = Coefficient of friction (usually 0.5)

3.3 Small Conductor Cables

In the case of small conductors where the permissible load is limited by 0.008 times the total circular-mil area of the conductors, the permissible load on the sheath may be added to that permitted on the conductor if the conductor and sheath are joined securely to the pulling eye.

3.4 Pulling Tension Requirements in Ducts and Conduits

3.4.1 Straight Run of Cable

For a straight run of cable, the tension is given by the following equation:

$$T = lwfv$$

where

T = pulling tension (lbs)
 l = length of duct (ft)
 w = weight of cable (lb/ft)
 f = coefficient of friction (usually 0.5) between cable(s) and duct or conduit surface
 v = occupancy factor
 1 cable per duct $v = 1.0$
 3 cables per duct $v = V_c$ or V_t from Fig 1

3.4.2 Curved Duct Sections

For curved duct sections, the following equation applies:

$$T_2 = T_1 e^{fa}$$

T_2 = Tension coming out of the bend (lbs)
 T_1 = Tension at the end of a straight section entering a bend (lbs)
 a = angle of bend in radians
 f = coefficient of friction (usually 0.5)

3.4.2.1 Values of e^{fa} .

Values of e^{fa} commonly used are listed below:

Bend Angle in Degrees	Value of e^{fa^*} [2]
15	1.14
30	1.30
45	1.48
60	1.70
75	1.94
90	2.20
105	2.50
120	2.86

*NOTE: Coefficient of friction is 0.5.

3.4.2.2 Minimizing Pulling Tension

In order to minimize the pulling tension on the cable(s), the cable should be fed into the duct run from the end nearest the bend.

3.5 Check List Prior to Pulling Cable

- 1) Be sure there is adequate clearance between duct or conduit diameter and cable diameter. Do not exceed recommended "percent fill" requirements.
- 2) Use adequate lubrication of the proper type to reduce friction in conduit and duct pulls. The grease and oil type lubricants used on lead sheathed cables should not be used on non-metallic sheathed cables. There are a number of commercially available wire pulling compounds that are suitable for use with non-leaded cables.
- 3) Avoid sharp bending of the cable at the first pulley in overhead installations by locating the pay-off reel far enough away from the first pulley that the lead-in angle is kept relatively flat.
- 4) After installation, check to determine that end seals are still intact and have not been damaged to the point where water could enter. Apply plastic or rubber tape to help protect against invisible damage if the cable will be subjected to immersion or rain. This is particularly important if there will be a delay of some time between the pulling operation and splicing and terminating.
- 5) In installing armored cables on rack, use sufficient rollers to prevent the cable from dragging on the rack, which might result in excessive tension. Avoid sharp bends in the cable by using one 3-sheave pulley at 45 degree bends and multi-roller sheave at 90 degree bends.
- 6) Keep adequate tension on the messenger in aerial cable installations to prevent sharp bends at pulleys. Do not release the tension on the messenger until it is secured to poles on both ends.

3.6 Methods of Gripping Cables for Pulling

3.6.1 General

In general, insulated cables may be gripped either directly by the conductors or by a basket-weave pulling grip applied over the cables. The method used depends on the anticipated maximum pulling tension. When pulls are relatively light, a basket-weave grip is used. Heavier pulls will require connecting to the conductor either by means of pulling eyes or by forming a loop with the conductor itself. In some instances, it is desirable to use a grip over the outer covering in addition to the conductor connection to prevent any slippage of one with respect to the other.