Industry Organizations

- Several professional organizations develop standards and guides for the power cable industry worldwide.
- A main goal of these organizations is to standardize on material, test procedures, and adopt best practices.
- The main organizations in the U.S. are the Institute of Electrical and Electronics Engineers (IEEE), Insulated Cable Engineers Association (ICEA), and Association of Edison Illuminating Companies (AEIC).
- Standards used outside the U.S. are developed by the International Electrotechnical Commission (IEC).
IEEE History

- IEEE is an association dedicated to advancing innovation and technological excellence.

- IEEE’s roots go back to 1884 when electricity was just beginning and has now become a major force in society.

- Originally formed as the American Institute of Electrical Engineers (AIEE) to support electrical engineering professionals and to help them apply innovation.

- The Institute of Radio Engineers (IRE) was formed in 1912 (and modeled after AIEE) to support the radio and electronics field.

- AIEE and IRE merged in 1963 to form the IEEE. At that time they had 150,000 members, with 140,000 in the U.S. Today IEEE has about 400,000 members in 160 countries.
IEEE has numerous Standards, Specifications, and Guides related to the power cable industry. A few key standards and guides follow:

**IEEE 48** - IEEE Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV Through 765 kV.

Covers all indoor and outdoor cable terminations used on alternating-current (AC) cables with laminated or extruded insulation rated from 2.5 kV through 765 kV. Cable terminations and component parts manufactured for these voltages shall be capable of withstanding the tests and requirements as specified in this Standard.

The guide describes and discusses techniques for measuring ground resistance and impedance, earth resistivity, potential gradients from currents in the earth, and the prediction of the magnitudes of ground resistance and potential gradients from scale model tests.

It also covers factors influencing the choice of instruments used and the techniques for various types of measurements. It includes the purpose of the measurements, accuracy required, type of instruments available, possible sources of error, and nature of the ground or grounding system being tested.
Insulated conductors in service are subjected to voltage surges from lightning, switching, and other sources. These surges vary widely in wave shape, magnitude, and frequency of occurrence.

This procedure was developed to simulate in service conditions and is intended as a guide for impulse testing of cables and cables with accessories (cable systems). It can be used as a qualification or design test for cables and/or cable systems.

Procedure covers the method for testing and determining the radial power factor of insulating tapes of an oil impregnated insulated power cable.

The power factor determines the insulating quality and condition of each insulating tape in a power cable system.
IEEE 100 - Authoritative Dictionary of IEEE Standards Terms

Publication includes technical terms and definitions used in all IEEE standards and guides from several industries (Communications, Power, Information Technology, etc.).

It also provides a list of the IEEE Standards and Guides.

Guide lists various field test methods currently available or under development with a guidance on how to perform each test, along with advantages and disadvantages of each test.

It covers shielded, insulated power cable systems rated from 5 kV through 500 kV.
IEEE 404 - Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V.

Standard establishes electrical ratings and test requirements for cable joints used with extruded and laminated dielectric shielded cable rated from 2500 V to 500,000 V. It also defines a variety of common joint constructions. The standard is designed to provide uniform testing procedures that can be used by manufacturers and users to evaluate the ability of underground power cable joints to perform reliably in service.
Provides recommendations for the properties, characteristics, design, and testing of various types of cable jackets. The guide ensures that jacket materials are suitably specified for their intended applications. Also, jackets should provide a level of electrical, thermal, mechanical, and chemical durability to ensure that cable performance is reliable under normal use, and without danger to the user or surroundings.

Describes common sheath-bonding systems now in use and methods of calculating sheath voltages and currents, particularly as applied to three-phase systems operating at 60 kV and above, with the neutral grounded directly or through an impedance.
IEEE 592 - Standard for Exposed Semiconducting Shields on High-Voltage Cable Joints and Separable Insulated Connectors.

Covers design tests for shield resistance and a simulated fault-current initiation for exposed semiconducting shields used on cable accessories, specifically joints and separable insulated connectors rated 15 kV through 35 kV.
IEEE 1142 - Guide for the Selection, Testing, Application, and Installation of Cables having Radial-Moisture Barriers and/or Longitudinal Water Blocking

Provides cable manufacturers and users with extensive information on design, testing, application, and installation of low, medium, and high-voltage power cables, as well as communication, control and instrument cables that make use of metal-plastic laminates as radial-moisture barriers.

The guide also addresses additional means of protecting cables from the entrance of moisture through use of polymeric super absorbent materials for longitudinal water blocking of stranded conductors and other spaces within the cables.
IEEE 1299 - Guide for the Connection of Surge Arresters to Protect Insulated, Shielded Electric Power Cable Systems.

The guide suggests surge arrester installation methods at distribution cable terminal poles in order to minimize the total impressed transient voltage on medium-voltage distribution cables.

Different protection schemes are included to assist the user in designing overvoltage protection for cable systems.
IEEE 1300 - Guide for Cable Connections for Gas-Insulated Substations.

The guide establishes typical dimensions for connections of a gas insulated substation (GIS) to extruded, self-contained fluid filled and high pressure fluid filled (pipe type) cables in single and three phase arrangements for voltages 72.5 kV to 550 kV.

Connecting a GIS to cables requires coordination of design, material, installation and test procedures of several manufacturers and designers. The guide provides detailed directions for such coordination.
IEEE 1333 - Guide for Installation of Cable Using the Guided Boring Method.

Considers the method and equipment involved in proper and economical installation of insulated conductors and/or conduits using the guided boring method. The method may be used to install insulated cable, cable preinstalled in conduit, or conduit alone.

The purpose of this guide is to provide users of high-pressure fluid-filled (HPFF) pipe cable systems and self-contained fluid-filled (SCFF) or Low Pressure Fluid Filled (LPFF) cable systems with the basis to establish the use of gas-in-fluid analysis for diagnostic purposes and as an operating maintenance tool.
The guide provides technical information regarding factors that can affect the life of an impregnated paper insulated transmission cable system, and it reviews available methods to evaluate the remaining life of such systems and preventive maintenance to extend their service life.
IEEE 1511 - Guide for Investigating and Analyzing Power Cable, Joint, and Termination Failures on Systems Rated 5 kV through 46 kV.

Purpose of the guide is to provide an introduction to the concepts of failure analysis, how it can be used, and the value that can be obtained. The guide covers some commonly used methods employed in failure analysis and how these methods can be applied in determining the cause of failure of components used in construction of an underground power cable system.

IEEE standards and guides can be obtained through GU’s Library website.
Association of Edison Illuminating Companies (AEIC) was organized in 1885 to provide guidance to Edison illuminating companies within the USA.

Initially, the organization’s function was to license the illuminating companies to use Edison’s inventions and patents.

After the companies went their separate ways in 1895, AEIC became more of an electric industry association, seeking improvements to the technological aspects of the industry.
CS1-90 Specification for Impregnated Paper-Insulated Metallic-Sheathed Cable, Solid Type (11th Edition)

Specification covers manufacturing and testing requirements that apply to impregnated paper insulated solid type power cables with metallic sheaths used at transmission and distribution voltages.
The specification covers manufacturing and testing requirements that apply to impregnated paper insulated and laminated paper polypropylene insulated cables for High Pressure Fluid Filled (HPFF) and High Pressure Gas Filled (HPGF) power cables.
CS3-90 Specification for Impregnated-Paper-Insulated Metallic Sheathed Cable, Low Pressure Gas-Filled Type (3rd Edition)

Covers manufacturing and testing requirements that apply to impregnated paper insulated low pressure gas filled type power cables with metallic sheaths used at transmission and distribution voltages.
CS4-93 Specification for Impregnated- ...

CS4-93 - Specification for Impregnated-Paper-Insulated Low and Medium Pressure Self-Contained Liquid Filled Cable (8th Edition)

Specification covers manufacturing and testing requirements that apply to impregnated paper insulated low and medium pressure fluid filled type power cables with metallic sheaths used at transmission and distribution voltages.
Specification covers manufacturing and testing requirements that apply to power cables 5 kV to 46 kV insulated with various types of crosslink polyethylene and ethylene propylene rubber insulated cables.
CS9-06 Specification for Extruded Insulation Power Cables and Their Accessories Rated 46 kV through 345 kV ac (1st Edition)

Specification evolved from CS7 and describes design and test requirements for solid dielectric cables with cross-linked polyethylene and ethylene propylene rubber insulated power cables rated above 46 kV through 345 kV voltage range.

Note: AEIC CS7 was replaced by AEIC CS9

Guide covers proper operating temperatures and operating temperature limits and the effects it has on the operation of the power cable with paper and paper laminated insulation.
Provides various construction techniques relating to the installation of HPFF and HPGF cable systems, including the following topics:

- General installation requirements
- Trenching and backfill requirements
- Steel pipe handling
- Installation instructions for coated steel pipes
- Installation instructions for pipe-type cable and accessories
Guide provides various construction techniques relating to the installation of extruded dielectric cable systems. It helps users prepare installation specifications for cables rated 69 kV through 138 kV voltage range.
Guide outlines the pulling parameters that need to be considered when designing and installing power cables in duct. The guide covers extruded cables only.
Guide covers proper operating temperatures and operating temperature limits and the effects it has on the operation of the power cables with extruded dielectric insulation.

Covers considerations that are addressed in pursuing courses of action available for cable replacement or cable life extension in power cables ranging from 5 kV through 46 kV.

Describes techniques and procedures that can be used to establish a quality assurance program for extruded dielectric cables. These procedures will help ensure that the purchaser consistently receives cable as specified.
CG9-00 Guide for Installing, Operating, and Maintaining Lead Covered Cable Systems Rated 5 kV through 46 kV (1st Edition)

Guide covers the most common material and techniques associated with the installation and maintenance of paper insulated lead covered (PILC) cables.
Guide describes the various choices that an engineer must consider when developing a cable specifications for cables ranging from 5 kV to 46 kV.

The guide is also designed to familiarize the user with the criteria required to ensure the cable will perform as intended.
Guide covers design criteria that should be considered when specifying reduced diameter extruded dielectric power cables ranging from 5 kV to 46 kV.

It also covers the effects reduced diameters cables will have on the accessories.
CG12-05 Guide for Minimizing the Cost of Extruded Dielectric Shielded Power Cables Rated 5 through 46 kV (1st Edition)

Provides general information that can be used to reduce the initial cost of extruded dielectric cables rated at 5 kV through 46 kV. However, each design variable may have an effect on the performance of the cable and the cable accessories.

AEIC publications can be obtained through the AEIC website: www.aeic.org
Insulated Cable Engineers Association (ICEA)

- Insulated Cable Engineers Association (ICEA) is a professional organization dedicated to developing cable standards for the electric power, control, and telecommunications industries.

- ICEA was founded in 1925, the members are typically cable manufacturers, engineers and consultants.

- A listing of key ICEA standards and guides related to the power cable industry are provided on the following slides.
ICEA P-45-482 - Short Circuit Performance of Metallic Shields and Sheaths on Insulated Cable.

Equations and parameters have been established for short circuit calculations for sheaths or shields made of aluminum, bronze, copper, lead, steel, zinc and cupro-nickel alloy. The types of sheaths or shields included are:

- Wires, applied helically, as braid or serving; or longitudinal with corrugations.
- Helically applied flat tape, not overlapped.
- Helically applied, overlapped, flat tape.
- Corrugated tape, longitudinally applied.
- Tubular sheath
ICEA S-81-570 – 600 Volt Rated Cables of Ruggedized Design for Direct Burial Installation as Single Conductors or Assemblies of Single Conductors

Standard applies to the materials, construction, and testing of single conductor cables and assemblies of completed single conductor cables used for distribution of electrical energy at phase-to-phase voltages not exceeding 600 volts or phase-to-ground not exceeding 480 V, and at temperatures not exceeding 75°C or 90°C, as applicable to the construction.
ICEA S-94-649 – Concentric Neutral Cables Rated 5 kV through 46 kV.

Standard applies to materials, constructions, and testing of crosslinked polyethylene, tree retardant crosslinked polyethylene and ethylene propylene rubber insulated single conductor or multiplexed concentric neutral cables rated 5 kV to 46 kV which are used for the transmission and distribution of electrical energy.

Applies to materials, constructions, and testing of 5,000 volt to 46,000 volt shielded crosslinked polyethylene, and ethylene propylene rubber insulated wires and cables which are used for the transmission and distribution in the electrical energy for normal conditions of installation and service, either indoors, outdoors, aerial, underground, or submarine.
ICEA S-97-682 – Utility Shielded Power Cable Rated 5 kV through 46 kV

Standard applies to materials, constructions, and testing of crosslinked polyethylene, tree retardant crosslinked polyethylene and ethylene propylene rubber insulated single conductor or multiplexed shielded power cables rated 5 kV to 46 kV which are used for the transmission and distribution in the electrical energy.
ICEA S-108-720 – Standard For Extruded Insulation Power Cables Rated above 46 to 345 kV.

Applies to materials, constructions, and testing of cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR) insulated single conductor shielded power cables rated above 46 kV to 345 kV used for the transmission of electrical energy.

Covers how to detect and measure partial discharges occurring in single and multi-conductor cables.

Guide provides a combination of plans for the frequencies at which cable samples may be obtained for tests to determine conformance to appropriate requirements of ICEA Standards Publications. Valid statistical sampling frequencies other than those listed herein are acceptable if evidence of statistical control can be demonstrated.

The guide applies only to extruded dielectric power, control, instrumentation, and portable cables.

Provides a procedure which is suited for determining the relative degree of crosslinking of polymeric, electric power cable insulations during manufacturing.

ICEA publications can be obtained from the ICEA website: www.icea.net

IEC is the world’s leading organization for the preparation and publication of International Standards for all electrical, electronic and related technologies, known collectively as “electrotechnology”.

Key IEC standards and guides related to the power cable industry are listed in the following slides.
IEC 62067 – Power cables with extruded insulation and their accessories for rated voltages above 150 kV ($U_m = 170$ kV) up to 500 kV ($U_m = 550$ kV) – Test methods and requirements.

Standard specifies test methods and requirements for power cable systems and their accessories with extruded insulation rated from 150 kV up to 500 kV.
IEC TS 60589 – Cable connections for gas-insulated metal-enclosed switchgear for rated voltages 72.5 kV and above. Fluid-filled and extruded insulation cables – Fluid-filled and dry type cable terminations.

Specification covers the connection of cables into gas insulated metal enclosed switchgear for single or three phase cable arrangements for fluid filled or extruded cable systems.

IEC publications can be obtained from the IEC website: www.iec.ch