History of the National Electrical Safety Code ANSI C2

The National Electrical Safety Code

The National Electrical Safety Code [NESC] is the American National Standard for the safety of electric supply (power) and communication utility systems installed and maintained under qualified control by public or private utilities. It applies to generation, transmission, and distribution of electric energy and communication signals from inception or receipt from another entity up to the *service point* where it is transferred to a premises wiring system (where it comes under the jurisdiction of the National Electrical Code NFPA 70 [NEC]).

The NESC is adopted by state legislatures and public service commissions (the NEC is adopted by state or local building code officials or insurance departments).

Use of the NESC

The NESC is adopted in whole or part by most states in the United States of America (a few only adopt the construction rules and not the work rules). A couple of states do not directly adopt a safety code for utilities, but use the latest edition of the NESC whenever subjects within its scope arise. California is the only State that has its own state code; California reviews its requirements whenever the NESC is revised.

The NESC is used throughout the Caribbean islands, in US Territories, and on US military bases throughout the world. The NESC has also been used by US consulting engineers in electrifying third world nations under the USAID programs in cooperation with the US Department of Agriculture's Rural Utility Services (formerly Rural Electrification Administration) program. The NESC is used in approximately 100 countries around the world, sometimes with appropriate modifications for temperature, ice, or wind differences.

Current NESC Organization and Operation

The NESC Committee is composed of a single voting representative from each of the member organizations plus the current Chair and Past Chair. The member organizations are approved by the NESC Main Committee as having a balance of the interests involved. The Procedures under which NESC revisions are made are approved by ANSI.

In 1972, he NESC Committee selected IEEE Standards (now IEEE Standards Association [IEEE-SA]) staff of the Institute of Electrical and Electronics Engineers (IEEE) as its Secretariat. The NESC Secretary is an IEEE staff member. The IEEE Standards Staff provides support functions to assure smooth NESC operation.

Technical subcommittees are appointed to review assigned portions of code requirements. Although most technical subcommittee members are nominated by member organizations, several subcommittee members who are recognized experts in their respective fields have been nominated by other organizations that are not members.

Technical subcommittees appoint Working Groups and Task Forces as needed to accomplish the work. Members of these groups need not be nominated by a group. Some are recognized experts who are invited to join the work of the subcommittee. Although the NESC is primarily geared toward utility operations in the United States of America, there are international technical experts working with NESC subcommittees at various levels.

The NESC revisions occur on a set schedule, with each edition of the Code carrying the schedule for the next edition in it, including directions on how to make proposals for change. The revision process is very public—anyone can make a change proposal (CP)—and anyone can comment on proposed changes.

After CPs are received, they are assigned to relevant technical subcommittees for review. Votes at the subcommittee level are a simple majority. Regardless of whether a proposal is initially recommended, changed, or rejected, both the initial proposal and the subcommittee actions are published in a Preprint of proposed changes. Anyone can comment on these proposed changes.

After a comment period, any comments on proposed actions published in the Preprint are reviewed by the relevant technical subcommittees. Voting is again a simple majority at the level.

After review of the Comments, the ballot copy is prepared and sent to the member organizations for review and the final vote. The final vote of the Main Committee requires a 75% approval to accomplish a change.

If there are negative ballots, the NESC Executive Subcommittee will address negative ballots. At present, the new code edition is published on the first day of August of the year preceding its effective date. Under present rules, the effective date is the first day of February of the year of the edition name (the first day of the month following expiration of 180 days from the date of publication).

NESC Official Interpretations

The NESC Committee maintains an Interpretations Subcommittee to answer questions about the intended application of the NESC. Under the required procedures, the IR Subcommittee is not allowed to answer questions such as *"Does XYZ meet the NESC?"*; it can only answer questions concerning potential uncertainty or ambiguity in wording. NESC Interpretations are essentially "*case law"*, in that they serve as the official explanation of the intention of code requirements until such time as the rules are modified (if ever). NESC subcommittees review all recent Interpretations as part of each code revision cycle to see if modifications of code language are needed.

In the 1970s, IEEE gathered all records of previous Interpretations and published them in a set of hardbound, archival books. In 1992, when all of those books were gone, the group of books was published as a thick paperback. This paperback was updated in 1997. All IRs and Answers from 1997 to date are available on the internet from the NESC Zone on the IEEE Standards web site. http://standards.ieee.org/about/nesc/ As this is written, the older ones of 1997 and prior dates are being digitized and will be available electronically at some future date.

Tentative Interim Amendments

A Tentative Interim Amendment (TIA) process allows interim changes to a particular NESC edition(s) if they are deemed sufficiently critical. Tentative Interim Amendments are in effect through the conclusion of that specific edition, and will be reconsidered for inclusion in the subsequent edition, during the next revision cycle process (unless they are intentionally rendered to correct language in an older edition). Copies of TIAs are available from the NESC Zone of the IEEE web site: http://standards.ieee.org/about/nesc/.

IEEE NESC Handbook

It became readily apparent in the late 1970s and early 1980s that utility personnel had questions about code application from time to time for which there was no ready source of answers. IEEE through the

NESC Secretary assisted the Chair of the NESC Interpretations Subcommittee in locating all known documents relating to the initial preparation of the NESC. Some had been transferred to IEEE from the National Bureau of Standards; others were found in the libraries of long-time or retired code subcommittee members. The first edition of the IEEE NESC Handbook was published in 1984 as a companion to the 1984 NESC.

During the original preparation of this Handbook, every document known to exist concerning the codification of the NESC through the 1984 Edition was reviewed, including all past editions of the NESC, the Official Interpretations, the Official Discussions issued by the National Bureau of Standards (the first Secretariat of the NESC), previous drafts of various editions, and subcommittee minutes from 1984 and earlier discussions. Extensive discussions were held with living subcommittee members from the 1960 6th Edition and later editions, some of whom also provided access to personal notes from meetings, including a draft of an Official Discussion of the 6th Edition that was never published and early, unpublished drafts of published Discussions.

During preparation of the 2nd and later Editions of the NESC Handbook, all Official Interpretations, Change Proposals, Preprints, Comments, and meeting minutes have been reviewed by the Editor and Subcommittee Reviewers to provide guidance to code users. In addition, many of the discussions in the NESC® Handbook: A Discussion of the National Electrical Safety Code® published by the IEEE Standards Association came directly from subcommittee requests to provide information that has been considered by the subcommittees during the review process to aid code users in understanding why the code requirements exist in their present forms and help them to determine when and how rules apply to specific local situations.

The assistance of NESC subcommittee officers and members during the intensive process of developing and updating the Handbook over the decades has been instrumental in helping to both assure accuracy and make the IEEE NESC Handbook be a practical, useful historical text.

The Handbook does not include the exact and complete text of NESC requirements; it is intended to be used as a companion to the Code as an aid in understanding the intended application of the text of the NESC rules. No statement therein is considered to be an official requirement or an official interpretation of the NESC. The requirements of the Code are solely contained in the document published as Accredited Standards Committee C2, National Electrical Safety Code by the Secretariat of the Code, the Institute of Electrical and Electronics Engineers, Inc.

Historical Codification and Revision of the NESC

Early electric supply and communications systems were isolated systems serving a specific town or area. They were constructed without standardization of clearances, strengths of materials, construction methods, or operation. As a result of the lack of standardization between systems and across systems, problems occurred for both public vehicles and electrical workers traveling from one area to another or working in different manufacturing facilities. Although many of the safety issues were directly related to electric supply utility and factory installations, others were related to telephone installations. Primary issues were clearance of energized parts from public and worker areas, strength of supporting structures, wiring methods, and electrical work methods.

These problems were further compounded as consumer use increased after 1900 and smaller systems were linked together to take advantage of economies of scale. An action by the public or an electrical worker that would be safe in one area might not be safe in another. In addition, as found by a 1919 joint survey of the National Bureau of Standards (NBS) and the National Electric Light Association, some electrical utility and factory installations were constructed, maintained, or operated in a *less than desirable manner*.

In response to these problems, and at the request of the US Congress, the National Bureau of Standards had started in 1913 to develop the National Electrical Safety Code to bring consistency and safety to the design, construction, operation, maintenance, and use of electric supply and communications installations throughout the United States.

The requirements of the original Code were based upon engineering theory and generally accepted good practice. They were codified after extensive research and public review, a practice that continues today. The National Bureau of Standards brought together representatives of the major players: electric utilities, telephone utilities, railroads, and factory owners to identify and discuss commonalities between systems, common problems, and potential solutions that were practical to achieve. The result was a practical, unified, national code that addressed potential problems that might be found in any area and on any kind of electrical or communication system.

Early NBS Circulars and Early National Electrical Safety Code Editions

A variety of documents were circulated among electric supply and communication utility professionals and building construction/maintenance personnel devoted to installation and maintenance of electric supply and communication utility systems and building wiring systems (premises utilization wiring systems) during the formation of the National Electrical Safety Code. Many of these were in the form of Circulars published by the National Bureau of Standards.

The First Edition of the NESC was intentionally not published for adoption—it was published for comment. Beginning with the Second Edition (the first edition to be adopted by any state), each new edition until the modern era of revisions starting in the 1970s required the existing utility system (and building utilization wiring system while those requirements were in the NESC) to be brought up to the requirements of the new edition. This continued until the so-called *grandfather clause* was added to each Part as it was revised in the 1970s (now contained in NESC Rules 013B2 and 013B3).

National Bureau of Standards Circular No. 49—1914

The 1st Edition of Bureau of Standards Circular No. 49—*Safety Rules to be Observed in the Operation and Maintenance of Electrical Equipment and Lines* was issued after a year of examination of appropriate requirements for electrical workers and electrical employees. This edition only covered work rules; it did not address clearances, grounding, or the strength of supporting line structures. It was issued primarily for discussion and was apparently not adopted by any states at the time, although it did result in changes in the work rules of some utilities.

National Bureau of Standards Circular No. 49, 2nd Edition—1915

The 2nd Edition of National Bureau of Standards Circular No. 49 carried the same title as the first edition (*Safety Rules to be Observed in the Operation and Maintenance of Electrical Equipment and Lines*) with the addition of *Being Part 4 of the Proposed National Electrical Safety Code* (2nd Edition). By then it was clear that work rules alone would not solve all the issues. Not only did additional issues of grounding, clearances, and strengths of structures and wires need to be addressed, but addressing those issues would best be done by grouping the discussions by categories in a new proposed national code. Work rules would be addressed in Part 4 of that code.

First Edition: National Bureau of Standards Circular No. 54—1915

National Bureau of Standards Circular No. 54 *Proposed National Electrical Safety Code—Preliminary Edition submitted for Discussion and Criticism—Not for Adoption* addressed the first three parts of the Proposed National Electrical Safety Code: the rules affecting the actual installations. Circular No. 49, 2nd Edition—1915 addressed the work rules of the proposed national code to be used in construction, operation, and maintenance.

Part 1. Rules for the installation and maintenance of electrical supply stations and equipment

Part 2. Rules for the installation and maintenance of electrical supply and signal lines

Part 3. Rules for the installation and maintenance of electrical utilization equipment

These proposed rules were intentionally put out for public comment and not for direct adoption. That process of allowing public comment on proposed changes to the Code continues today in the NESC procedures. This first edition of the NESC was never adopted by any state.

Part 1 covered only installations in electrical supply stations and continues to do so today. Pat 1 did not and does not cover installations in telephone central offices or equivalent installations of newer types of communication utilities, such as cable television antenna stations.

The majority of Part 2 covered overhead installations, but underground installations were addressed in Section 29 of Part 2. Part 2 included clearance requirements, strength requirements, and grounding requirements.

Part 3 covered utilization wiring accessible to personnel who were not qualified to work on or near electrical facilities; it applied to *factories, mercantile establishments, and similar places.* Over the years, all of these requirements have been transferred to ANSI/NFPA Std. 70, the National Electrical Code. In 1973, the underground rules were moved from Section 29 of Part 2 and expanded to become a new Part 3 for underground installations.

Appendix A included grounding requirements that applied to all three Parts. NOTES on intended application of the proposed Code were included at the back of the Bulletin.

Second Edition: National Bureau of Standards Circular No. 54, 2nd Edition—1916

After review of the proposed Code, the 2nd Edition was expanded and promulgated for adoption. It included expanding grounding rules in a new Section 9, where they remain today. The methods are contained in Section 9; the requirements that specify what must be grounded are contained in each Part of the Code. Parts 1-4 were included. New 500-series rules addressed special work issues relating to series lamp operation, meter operation, testing operations, tunnel and subway operation, commercial telephone and telegraph systems, and underground signal lines. This was a continuation of Part 4 and the 500 series rules were necessary due to the numbers of sections already used in the 400 series.

Like the first edition, comments on intended application of the different Parts were included, but they were located at the end of each Part and were renamed as DISCUSSIONS. These were the predecessors to the official Discussions of the NESC that were later issued as separate documents from the Code.

This edition required existing systems to be brought into compliance with the new rules or be guarded, which effectively brought them into compliance.

National Bureau of Standards Circular No. 72—1918

Circular No. 72 *Scope and Application of the National Electrical Safety Code* was issued to answer questions about how the Code had been developed and how it was intended to be used. It included summaries of the requirements of the different Parts, discussions of appropriate inspections, and 100 typical accident cases involving injury to both members of the public and electrical workers and both inside and outside of buildings. It also included typical cases of resuscitation after electrical shock.

Third Edition: National Bureau of Standards Handbook No. 3—1920 (NESC) and Handbook No. 4—1920 (Discussion)

By the 3rd Edition of the NESC, published as Bureaus of Standards Handbook No. 3 in 1920, the text and application of the requirements were well defined. With the exception of a few significant changes in the late 1930s and early 1940s, the requirements of the 3rd Edition continued with only minor changes until the 1970s.

The 3rd Edition added extensive tables of recommended sags and tensions for copper wires and iron and steel wires, strength information for poles and crossarms, pole setting depths, pole deterioration charts, etc.

Handbook No. 4 *Discussion of the National Electrical Safety Code* expanded the notes and discussions of the earlier editions of the NESC into a separate document. This Discussion was extensive and the Handbook was almost as large as the Code itself. This official Discussion of the 3rd Edition of the NESC and those of the 4th and 5th Editions served as the starting point for the present-day IEEE NESC Handbook that was first published in 1984.

Throughout the rest of the tenure of the Bureau of Standards as the Secretariat of the NESC until 1972, revisions of the NESC were published as Bureau of Standards Handbooks.

Fourth Edition: National Bureau of Standards Handbook No. 3—1926 (NESC) and Handbook No. 4—1928 (Discussion)

The 4th Edition of the NESC was published in Bureau of Standards Handbook No. 3 in 1926. It included the original four Parts plus a new Part 5 addressing radio installations. The appendix tables in Part 2 were expanded significantly with new tables for steel cable, copper-covered steel wire and cable, and aluminum wire and cable.

The work rules in Part 4 were revised to absorb all of the 500-series rules not associated with radio installations. The new Part 5 *Safety Rules for Radio Installations* included requirements for clearances, wire strength, and strength of supporting structures (most antennas were wire antennas strung between posts or poles), and lead-in conductors, etc. The requirements of Part 5 were eventually absorbed into the NEC in Article 800 in the 1950s and 1960s and were removed from the NESC prior to the 1973 Edition of the NESC.

After publication of Handbook 3 in 1926, the official Discussion was updated over the next two years and published in 1928.

The Fourth Edition is the first edition in which individual Parts of the NESC were also issued as individual Bureau of Standards Handbooks.

1. Handbook No. 6. February 1926—Electric Supply Stations: Part 1 and the Grounding Rules of the NESC 4th Edition.
2. Handbook No. 7. March 1926—Electric Utilization Equipment: Part 3 and the Grounding Rules of the NESC 4th Edition.
3. Handbook No. 8. July 1926—Operation of Electrical Equipment and Lines: Part 4 of the NESC 4th Edition.
4. Handbook No. 9. July 1926—Radio Installations: Part 5 of the NESC 4th Edition.

5. Handbook No. 10. April 1927—Electrical Supply and Communication Lines: Part 2 of the NESC 4th Edition. This Handbook also included the extensive appendix data on wire sags and tensions and pole strength.

Fifth Edition: issued as individual Parts and Compilations of Parts in a variety of National Bureau of Standards Handbooks from 1938 through 1949 [some approved by the American Standards Association]

As was typical of the time, the subcommittees responsible for the different Parts of the NESC started work at the same time, but some finished earlier than others. As a result, individual Handbooks containing singular Parts were issued before the compilations of Parts. These Handbooks were numbered sequentially with the Parts of the Code (Hbk 30 was to be the complete NESC, Hbk 31: Part 1, etc.), but they were issued out of order as they were finished. The following list shows the order of publication of the individual Parts of the 5th Edition.

Handbook No. 34, October 1938 (supersedes Circular 49 and H8): Operation of Electric Equipment and Lines: Part 4 of the NESC 5th Edition [ASA 1939]

The work rules were the first Part revised for the 5th Edition. This was the first edition to:

1. require tagging, marking, or lettering lines if they could not be identified by location,
2. require employees in doubt of work to be performed to request further instructions,
3. recommend covering grounded facilities located adjacent to energized facilities being worked with insulating materials, and
4. prohibit using metal or metal-reinforced tapes, hoses, or flashlights around energized parts.

Handbook No. 35, December 1939: Radio Installations: Part 5 of the NESC 5th Edition [ASA 1940]

All of these rules were later added to the Article 800 series of the National Electrical Safety Code and removed from the National Electrical Safety Code.

Handbook No. 33, January 1940 (supersedes H7): Electric Utilization Equipment: Part 3 and the Grounding Rules of the NESC 5th Edition [ASA 1941]

The 5th Edition is the last NESC edition containing rules for utilization wiring systems. All of these rules pertaining to premises wiring systems were added over time to the National Electrical Code (ANSI/NFPA 70) [NEC] and were officially removed from the National Electrical Safety Code in 1970. Removal of premises wiring requirements from the NESC was the result of the dichotomous adoption of safety codes by individual states.

The NEC is generally adopted as a part of state (or local) building codes by Building Code Councils/Commissions that are usually associated with the state department of insurance or a city or county government, whereas the NESC is typically adopted by the state public service commission that regulates utilities or required by statute. Although the original intent of Congress was to have both the utility wiring code and the premises wiring code be published in one document, so that there would be one, national code that applied to all electrical supply and communication installations, that did not prove practical.

Today, the number Part 3 is reused and applied to the expanded underground rules promulgated in 1973.

Handbook No. 36, April 1940: Electric Fences: Part 6 of the NESC 5th Edition

This Part was removed from the National Electrical Safety Code prior to the 6th Edition. There is no ANSI standard on electric fences, but the American Society of Agricultural and Biological Engineers (formerly American Society of Agricultural Engineers) does have a standard *ASAE/ASABE EP568 (R2011) Installation of Electric Fence Controllers* intended to aid manufacturers in design and in preparing instructions for use.

Handbook No. 31, May 1940 (supersedes H6): Operation of Electric Equipment and Lines: Part 1 and the Grounding Rules of the NESC 5th Edition [ASA 1941]

The 5th Edition was approved as a National Standard by the American Standards Association. This was the last edition of the NESC before the so-called *grandfather clause* was added in NBS Handbook 110-1 issued in June of 1972. Thus, (a) earlier electric supply station installations (substations, power plants, and transmission switching stations) had to be brought into compliance with the 5th Edition requirements and (b) the 5th Edition is the oldest that can apply to facilities installed before 1972 that have not been brought into compliance with a later edition.

The 5th Edition was the first to recognize sealed batteries versus unsealed ones in battery rooms.

Handbook No. 32, September 1940 (supersedes H10): Electric Supply and Communication Lines: Part 2 and the Grounding Rules of the NESC 5th Edition [ASA 1941]

Only minor changes were made to the grounding rules, overhead clearance rules, and underground rules. The major changes were in the strengths and loadings rules.

The demarcation line between the Medium Loading District and the Heavy Loading District was shifted up from the lower Tennessee and North Carolina borders to upper Kentucky border, lower west border of Virginia and up through mid-Virginia.

The wind pressure was reduced from 8 psf to 4 psf for the Medium and Heavy Loading Districts, and from 12 psf to 9 psf in the Light Loading District in order to recognize the fact that wind speeds decrease on structures as they approach the ground. In order to effectively retain the original wind pressures on conductors for purposes of conductor tension at angles, deadends, conductor hardware, etc., a system was devised to add a constant back to the resultant of conductor wind force and conductor weight to determine the total forces to be used in calculating conductor tension.

The previous Grade A Construction requirements were removed in this edition and portions of the requirements were combined with Grade B.

The transverse (across the line) strengths were doubled for both Grades B and C construction.

Design information about the characteristics of materials was removed from the Code.

Handbook No. 39, July 1944: Discussion of the NESC: Part 2 and the Grounding Rules of the NESC 5th Edition

Only the grounding rules of Section 9 and Part 2 (overhead and underground supply and communication lines and equipment) of the 5th Edition were discussed in this Discussion handbook.

Handbook No. 30, March 1948 (supersedes H3): National Electrical Safety Code: Grounding Rules and Parts I, II, III, IV, and V of the NESC 5th Edition

This is the first time that all parts of the 5th Edition applying to electric and communication lines and equipment, utilization wiring, and radio installations were published in one document.

Handbook No. 43, August 1949: Comprising Part 2 and the Discussion of Part 2, the Definitions, and Grounding Rules of the NESC 5th Edition

This merely a reprint of the earlier portions of the 5th Edition that applied to overhead and underground lines and equipment.

Sixth Edition: November 1961 Bureau of Standards Handbook 81 containing Part 2 and the Grounding Rules [ASA 1960]

Only the overhead rules were revised for the 6th Edition. A fundamental change in voltage classifications occurred in the 6th Edition. When the NESC started, 3-wire ungrounded delta circuits were very common. For such circuits, there is no stable voltage to ground unless a ground fault detection system is used. Although use of a ground fault detections system on a delta circuit later became standard practice, it was not standard practice when the NESC started. As a result, all tables in the NESC used the phase-to-phase voltage.

By the 1950s, the predominant type of distribution circuit was a 4-wire, grounded wye circuit that had a definite voltage to ground. As a result, the tables of clearances to ground and to buildings were revised to use the voltage definition of the applicable circuit—thus the voltage used for a grounded wye circuit was the phase-to-ground circuit. The modern editions of the tables for clearances above grade and to buildings, etc., have clearly specified that the phase voltage to ground is used for grounded wye circuits and all other circuits (such as delta circuits with ground fault detection systems) that will be promptly de-energized upon a ground fault.

The table for clearances to ground had two columns of clearances for primary voltage circuits: 750 V to 15 kV and 15 kV to 50 kV. The table for clearances to buildings had three columns of clearances for primary voltage circuits: 750 V to 8.7 kV, 8.7 kV to 15 kV, and 15 kV to 50 kV. All classes of circuits except the 15 kV class (12.5/7.2 kV, 13.2/7.6 kV, 13.8/8 kV, etc.) had both the phase-to-phase voltage and the phase-to-ground voltage in one clearance column in both tables.

Because of the break points in the relative tables, this change to use the phase-to-ground voltage made no practical difference in clearances to ground, but it did shift the clearances to buildings to lower required clearances for those circuits of the 15 kV class, where the phase-to-ground voltage was below 8.7 kV. This was corrected in the next change to Part 2 of the NESC.

The 6th Edition was the first to completely prohibit using the earth normally as a sole return conductor. Previous editions had prohibited it in urban areas and recommended against it in rural areas.

Official Discussions

Whereas official Discussions of the NESC had been prepared by the subcommittees for previous editions, no official Discussion was completed by the subcommittees for this edition or any later ones.

> *NOTE: the unapproved draft of a Discussion of the 6th Edition and all of the official Discussions of previous editions served as the starting basis for the IEEE NESC Handbook first issued along with the 1984 NESC. The* NESC® Handbook: A Discussion of the National Electrical Safety Code® published by the IEEE Standards Association, *is edited by former NESC Chair Allen L. Clapp, PE with the assistance of NESC subcommittee chairs and secretaries to assure accuracy.*

Modern Editions of the National Electrical Safety Code

By the late 1960s, it was apparent that many areas of the Code needed significant revision to reflect recent advances in materials, designs, uses, and construction and operation techniques. This effort started under the direction of the National Bureau of Standards in 1968. Because of changes in the operations of the National Bureau of Standards, the NBS asked in 1972 to be relieved of its Secretariat duties. The Institute of Electrical and Electronics Engineers, Inc. (IEEE) was chosen as the new Secretariat and continues to serve as Secretariat.

The 1970s

Institute of Electrical and Electronics Engineers becomes NESC Secretariat

The National Bureau of Standards stopped acting as a Secretariat for technical committees like the NESC in 1972. The NESC Committee selected the Standards Staff of the Institute of Electrical and Electronics Engineers (IEEE) to assume that role in the same year. The IEEE Standards Staff brought continuity of effort and professional editing skills to the NESC revision efforts. The first NESC Secretary under IEEE was Conrad Muller, an experienced engineer with consummate editing skills and an ability to help engineers with diverse interests to find common ground and plan for the future. Under Muller's guidance, the NESC subcommittees moved from being mostly reactive toward preparing the Code to reflect expected changes in the electric supply and communication utility industries.

During the 1970s, the Overhead Clearances Subcommittee and the Overhead Strengths and Loadings Subcommittee met three to four times per year in preparation of the 1977 and 1981 Editions. Secretary Muller was instrumental in helping these two subcommittees in particular to revise terminology and language to better convey the required actions and prohibitions of the Code.

During the 1970s and through the later years, the IEEE Standards Staff has been of great assistance to NESC subcommittees in identifying and forging working relationships between the NESC and other code and standards committees to assure coordination between related codes and standards.

Because of the extensive changes in the overhead rules of the 1977 Edition, IEEE set up a national series of workshops to explain the changes to utility personnel and public service commission personnel. Primary instructors were Conrad Muller, NESC Secretary; Charles Blattner, Chair of the Electric Supply Stations subcommittee; Frank Denbrock, Chair of the Overhead Strengths and Loadings Subcommittee and Member (and later Vice-Chair) of the NESC Main Committee, and Allen Clapp, Overhead Clearances Subcommittee Working Group Chair for ground, rail, and water clearances and for building clearances and a Member (and later Chair) of the NESC Main Committee. Blattner, Clapp, and Denbrock were also members of the NESC Interpretations Subcommittee. These four individuals were the nucleus behind broad dissemination of knowledge about NESC changes and intended application of NESC rules during the late 1970s and early 1980s as the Code was modernized to reflect changes in issues, procedures, equipment, and methods. They literally spoke at hundreds of utility conferences during these years, either as a group or individually.

Introduction to 1970s era changes

Although revision of all Parts of the NESC and the Grounding Rules was started at the same time in 1968, the different Parts had dramatic differences in issues to be addressed and were issued at different times as they were finished. Part 1 was the first to be finished and was first issued as a separate NBS Handbook 110-1 in 1972.

The work rules were ready for publication by 1973, as was the expansion of the former Section 29 requirements for underground lines and equipment. However, Part 2 for overhead lines and equipment was not ready and would not be for several years. As a result, the **1973 Edition** was the first publication of all Parts of the NESC in decades; it reprinted Part 1 from NBS Handbook 110-1, reprinted Sections 20-28 and the Grounding Rules from the 1961 6th Edition, included the newly expanded underground rules as Part 3 (reusing the old Part number that had previously been used for the now deleted premises wiring rules), and included the revised work rules.

Part 2 required extensive revision to address new issues relating to clearances and to strength and loading requirements. New clearances were developed to reflect the relatively new practice of putting Citizens Band antennas on cabin-cruiser boats on lakes and the 1960s development of the high aspect ratio (tall relative to length) catamaran sailboats that were lightweight and trailerable. The strength and loadings rules had to be revised to address problems with high wind bringing down tall transmission lines (wind speed increases with height) and the incompatibility of earlier strength specifications with modern structural engineering calculation methodology. When the revisions of Part 2 and the Grounding Rules were approved, the revised Part 2, the revised Grounding Rules, and the reprinted Parts 1, 3, and 4 were published in the **1977 Edition**.

To help eliminate confusion, the naming system for the NESC was changed to refer to the year that it would become applicable. The first publication of NESC revisions under this system was the 1973 Edition. Once all Parts had been updated, all future editions would start and stop at the same time. Because of the large number of changes required to reflect modern practices and issues relating to overhead, underground, and work rules, the NESC started on a three-year revision cycle starting with the 1981 Edition (work for which started in 1977). Although the work was finished and the edition was published in September of 1980, it is called the 1981 Edition because the 1981 Edition was the first to specify an effective date of 180 days after publication. The new three-year cycle continued through the 1993 Edition. The cycle changed to a five-year cycle in the 1990s, after one interim four-year cycle for the 1997 Edition. Successive editions were the 2002, 2007, and 2012 Editions, with the 2017 Edition now in progress.

To help users of the Code, tables were renumbered to use the number of the rule associated with the table in its title. That practice continues today.

Part 1 for Electric Supply Stations

Part 1 was extensively revised in 1971, published as NBS Handbook 110-1 in 1972, and reprinted in the 1973 and 1977 Editions of the NESC. A significant change in this edition was to recognize that workers were significantly taller than when the Code started. This resulted in raising clearances for the lower voltage conductors and parts in substations, transmission switching stations, and power plants. Whereas previous editions had required the start of the guard zone around energized parts to be not less than 7.5 ft. above grade for lower voltage parts up to 11,000 volts and 8.5 ft. for higher voltage parts, Handbook 110-1 required the guard zone to start at 8.5 ft. above grade for all voltages. The 8.5 ft. starting point is still used today. Quite literally, you could march a brass band under energized parts in an electrical supply station without having the tuba player contact energized parts. This requirement allows plenty of room for electrical workers to move about the stations, wave at someone to get their attention over the fan noise, etc., without worry about contact with energized parts.

NBS 110-1 was the first of the Parts of the NESC to add the so-called *grandfather clause* to the code. This change was not so obvious in this edition, because it was accomplished by removing the language that required existing facilities to be brought into compliance with the new edition or be guarded.

NOTE: revisions of Part 3 in 1973 and Part 2 in 1977 used positive language to point out the change.

NBS 110-1 also added minimal provisions for grounding high-voltage direct-current (HVDC) electric supply systems that were beginning to be used for bulk transmission of power. These requirements were augmented during the next several editions of the NESC. Later editions clearly prohibit using the earth as a sole return for normal operation, but do allow it for emergency and test purposes.

Part 2 for Overhead Lines and Equipment

Part 2 was extensively revised in during the early 1970s. Ballots were issued in 1973, 1975, and 1976. Sections 20-28 of the 6th Edition of 1961 were reprinted in the 1973 Edition. Section 29 of the 6th Edition had been expanded into a new Part 3 in the 1973 Edition. The changes in overhead rules were approved in 1976 and published in the 1977 Edition, along with the reprinted Part 1, Part 3, and Part 4 rules.

Because the changes in Part 2 were the last to be completed for the 1977 Edition, a much clearer specification for application of the *grandfather clause* included in this edition.

1977 Grounding Rules

Different protection methods are used for ungrounded delta circuits and for solidly grounded 4-wire wye circuits. The system used to detect a ground fault on a delta circuit and de-energize the circuit cannot be used on a 4-wire grounded wye circuit, because transformers are directly connected between an energized phase wire and the grounded neutral on the 4-wire grounded wye circuits. As a result, it is critical to carry the neutral of a grounded wye circuit along to all connected equipment, so that an electrical short to the case of connected equipment will be detected and the circuit will be de-energized.

Although the 6th Edition had essentially prohibited carrying only energized phase conductors off of 4-wire grounded wye distribution line to serve three-phase pumps on an oil field, etc., the language was so subtle that it was missed by many. As a result, the 1977 Edition made it abundantly clear that the neutral was to be carried throughout the lines and, further, that not less than four ground electrode connections were required in each mile of line.

The 1977 Edition added specifications for concentric neutral cables and for concrete-encased electrodes that could be treated as a full grounding electrode at a transformer location and count in the overall requirement of four ground electrodes per mile of line.

1977 Overhead Clearance Requirements

The 1977 Edition recognized changes in character of lands being served by electric supply and communication lines. The character of rural lands was changing (in later editions, the rural category was removed entirely) and required increased specifications of clearances over rural lands and along rural roads. For the first time, clearances above water were added to address issues caused by high-masted sailboats with shallow drafts and antennas on boats. The 1977 Edition also greatly expanded the former clearances to buildings table to include clearances to other installations, such as tanks, signs, and antennas.

High-temperature conductor sags

The 1977 Edition was the first to specify how to account for conductor operation above 120 degrees Fahrenheit. Earlier codes specified clearances that were good up to 120 degrees F and left it to electric utilities with conductors operating at higher temperatures to appropriately take into account the increased conductor sag (decreased ground clearance) at higher temperatures.

The new specification required the utilities to calculate the sag change from 60 degrees F to the maximum temperature (if above 120 degrees F) and add that to the clearance required at 60 degrees F, final sag. The result was to intentionally require double counting of the first 1.5 ft. of sag change that was already included in the specified clearance at 60 degrees F. This intentional double counting of the first 1.5 ft. of sag change recognized that the conductor temperature calculation methodologies in use at the time had significant uncertainty associated with them.

After ANSI/IEEE Standard 738 was developed and personal computer programs were written in the 1980s, the 1987 Edition removed the double counting of the first 1.5 ft. of sag change for high temperature operation.

Pole location

The 1977 Edition was the first to specify location of poles next to roads that had no curbs and also clarified pole placement alongside roads with curbs.

Other lands with trucks

In previous editions, no clearance had been specified for rural lands, such as forests, grazing or cultivated lands, orchards, etc. This was intentional because some of these lands used very large equipment, such as a thrasher that would go down the road at a 12-ft. height and move up to a 23-ft. height to operate. The NESC had been reluctant to specify a clearance for these areas because there was no control over the height of the machinery to be used there. As activity by mechanized vehicles and trucks in these areas increased, it caused confusion for some utilities because of the relative lack of specificity in the original table for clearances to ground.

The original table was very simple; it included only clearances above rails, roads, streets, alleys, driveways, spaces accessible to pedestrians only, and along and within road rights-of-way but not overhanging the roadway. It is the latter category that caused confusion. Such areas in urban areas were required to have the full truck clearances; in rural areas, a clearance of 2 feet less was allowed (it allowed room for right-of-way maintenance tractors with mower decks or cycle blades to operate in rural areas). Unfortunately, because there was no direct specification for the forests, grazing or cultivated lands, orchards, etc., some utilities used the lower clearance which did not provide enough room for the full-height trucks that would be expected in those areas.

The 1977 Edition added a new clearance category applicable to *Other land traversed by vehicles such as cultivated, grazing, forest, orchard, etc.*, using the normal roadway truck clearances. Footnote 17 indicated that these clearances were good for vehicles up to 14 ft. high.

Water

Historically, utilities had used normal road truck clearances above waters for which a crossing permit had not been required. The US Coast Guard sets over-water obstruction heights for navigable waters in the United States, and crossing permits are administered by the US Army Corps of Engineers. Because large sailboats had deep keels, they were limited to water areas that required a crossing permit.

In the mid-1960s, a few accidents occurred on power line lake crossings after cabin-cruiser boat owners installed long, steel whip-type Citizens Band antennas on top of their boats. One of the first changes proposed at the 1968 start of revising overhead rules was a 25-ft clearance above water to accommodate such antennas. This problem was completely overshadowed by the popularization in the late 1960s and early 1970s of the lightweight, tall-masted catamaran sailboats that could be easily trailered to remote sites.

The 1977 Edition added new clearance categories for waters that were not suitable for sailboats (to accommodate fishermen in waders or standing in small skiffs or outboard motor boats) and for waters suitable for sailboats. The latter was based upon the size of the body of water because larger boats require more room for turning.

Also added were clearances above rigging and launching areas, because the mast is erected on the trailerable catamarans while the boat is on the trailer or on the ground. These were based upon the height of the waterline above ground while on the trailer and the room needed to step (install) the mast.

Buildings and other installations

The 1977 Edition was the first to address clearances for conductors operating at less than 300 V from buildings, and it expanded the specification of service drop clearances.

Several issues were addressed relating to clearances to buildings and other non-bridge installations. The industry had fundamentally changed since the 1961 publication of the 6th Edition. The advent of affordable air conditioning increased summer loads for many utilities several fold. To accommodate the demand efficiently, electric utilities increased voltages on existing lines and reconductored lines with larger conductors. The larger conductors were aluminum, instead of the previously used copper. Because aluminum has two-thirds the current-carrying capacity of copper conductors of the same size, aluminum conductors were larger. They were also lighter. The result was greater horizontal displacement of aluminum conductors under storm wind loadings than had been the case with copper conductors. Thus, for the first time, wind displacement of conductors was addressed in the NESC.

At-rest clearances

The 6th Edition change to allow use of the phase-to-ground voltage for grounded wye circuits resulted in a reduction in clearance for the 15 kV class of circuits (12.5/7.2 kV, 13.2/7.6 kV, 13.8/8 kV, etc.), where the phase-to-ground voltage was between 750 V and 8.7 kV. Previously, the horizontal clearance to buildings would have been 8 ft. based upon the phase-to-phase voltage being between 8.7 and 15 kV. After 1961, the clearance was reduced to 3 ft., because the phase-to-phase voltage was between 750 V and 8.7 kV.

The earlier copper lines using the lower clearance were almost always covered with layers of rubber with cotton mesh between them to protect the copper from industrial contaminants that would produce a hydrosulfurous acid and damage the conductor. Aluminum conductors did not have the same reaction to contaminants and were installed bare. Further, in earlier years, any building maintenance was done with a wooden ladder and a wooden-handled paint brush. Thus, there was no significant history of accidents to indicate to the 6th Edition subcommittee that clearances needed changing.

As time and circumstances changed, it became clear that the clearances to buildings needed to be reconsidered. A review of 10 years of recent accident data in the mid-1970s indicated that an at-rest clearance of between 7 and 8 feet would be appropriate at rest for circuits up to 15 kV.

Clearances under wind displacement

When the electric utility industry moved to aluminum conductors, the difference in weight and stretching characteristics between aluminum and copper conductors became readily apparent. Aluminum was lighter and had a larger diameter, thus allowing it to swing over more (larger displacement or swing angle) under wind loading. In colder climates with ice, where aluminum conductor with steel reinforcement ACSR was used, the problem was even worse because (a) less tension was used to accommodate the additional weight of ice and (b) the steel reinforcement strands were very stretchy to limit brittleness—ACSR will displace horizontally during wind loading more than all-aluminum alloy conductors which, in turn, will displace more horizontally than copper conductors.

When Interstate Highways started being built, billboards and signs were placed along the Interstate Highways to tell motorists where to turn to get gas, food, and sleeping rooms. Those billboards and signs were lighted by running long spans of (usually) #4 AWG ACSR conductor along the highways. The horizontal displacement of some of those conductors under storm loading was enough to contact nearby signs and tobacco barns. Thus, addressing displacement of conductors due to wind loading was an important change in the 1977 Edition.

Combined at-rest and wind clearance

Both the required at-rest clearance and required clearance under wind displacement were considered in the final resolution. The table for clearances to buildings (which changed to Table 234-1 in this edition) was changed to specify the horizontal clearance that must be left *after* the conductor was displaced by a 6 lb/ft^2 (psf) wind pressure (rounded off from the 6.4 psf that would be produced by a 50 mph wind) was 5 or more feet, depending upon the voltage. The result was to effectively move the at-rest clearance back out between 7 and 8 feet even on the shorter spans.

Additional clearances

Clearances to buildings were expanded to specify vertical clearances based upon access to roofs and balconies over which lines might run, as well as heights of vehicles on loading docks, parking decks, etc.

In addition, a second part of the table was added to specify clearances for other installations, such as tanks, signs, antennas, etc., where a worker might go up to the top to paint it, fill it, change letters, etc., but would not stand directly on it.

> *NOTE: later editions added clearances to catwalks or other areas on such installations upon which a worker might walk erect.*

Swimming pool and grain bin clearances

Swimming pool clearances were added to recognize the proliferation of personal swimming pools and provide clearances for skimmer poles and rescue poles.

Grain bin clearances were added to recognize the room needed to use portable augers and to use probes to sample grain or take temperatures inside the bin.

1977 Overhead Loading and Strength Requirements

The main changes to overhead loading and strength requirements were to require consideration of extreme wind on taller lines and structures, revise the specification system for limiting stress on components, and recognize newer materials. The 1977 Edition was the first to require using the highest grade of construction, Grade B, above Interstate and other limited access highways.

Extreme wind

In the 1960s, several hundred miles of transmission lines carried on tall structures came down under bare wind loading (no ice) storm conditions. Investigation revealed that use of the larger conductors at greater distances above ground caused the problem. Wind speed, and thus wind pressure, increases with height above ground. A 90 mph wind speed translates to 20.74 psf, which is over 5 times larger than 4 psf used in the traditional ice/wind loading combination.

The traditional ice/wind loading combination included a 4 psf wind pressure applied to a conductor covered with either 0.5 in radial ice (Heavy Loading District) or 0.25 in radial ice (Medium Loading District). A 0.5 in radial ice covering would increase conductor diameter by 1 inch. Thus, a ¼-inch diameter conductor would increase to 5 times its original diameter, but a 1-inch diameter conductor would only increase to twice its original diameter. Thus an ice/wind factor of 5 x 4 = 20 would apply to the ¼-inch diameter conductor with ice and wind, but an ice/wind factor of only 2 x 4 – 8 would apply to a 1-inch diameter conductor. It is easy to see that the extreme wind loading on bare conductor and traditional ice/wind loading on the ¼-inch diameter conductor are equivalent, but the extreme wind loading on a bare 1-inch diameter conductor is 2.5 times that of the traditional ice/wind combination.

Thus, a new extreme wind loading map was added in the 1977 Edition. At the time of these decisions, the average distribution line pole length was only 35 ft. With a setting depth of 6 ft., none of the conductors would be as high as the 10 m (33 ft.) level at which wind data was taken or translated. Experience at the time did not show the need to require distribution line designers to calculate extreme wind loadings, so the extreme wind load case was not required unless either the structure or the conductor was more than 60 ft. above ground.

> *NOTE: Today, with the use of even larger conductors and multitudes of large communication cables, taller poles are now being installed and distribution is now experiencing the same kind of failures under bare wind loadings. As a result, the 2017 Edition is expected to remove the 60-ft. level exemption and apply extreme wind loading to all structures.*

Calculations

Previous editions of the NESC had required the stress under specified loadings not to exceed an allowed percentage of the strength of the material in each direction of loading. For example, limits would be XX% in transverse (across the line) loading, YY% in longitudinal (in-line) loading, and ZZ% vertical loading. However that kind of specification did not allow easy calculation of the result of simultaneous loading. As a result, factors were upended: a limit of 25% of the rated breaking strength of the material became a load factor of 4.00. As a result, the resultant of simultaneous loads in different directions could now be calculated and addressed.

Concrete

In concrete poles, concrete takes the compressive forces and steel rods take the tension forces. Pre-stressed concrete differs significantly from reinforced concrete. The difference is that the metal reinforcing in pre-stressed concrete does not elongate much more when it receives maximum loading.

As a result any cracks that occur are small and eccentric loading that might result from large bending movements of the pole are limited. The metal reinforcing in reinforced concrete is not pre-stretched. Thus, reinforced concrete pole bend more under maximum loading and have deeper cracks form.

The 1977 Edition created separate requirements for pre-stressed concrete pole; reinforced concrete and wood poles have essentially the same requirements, due to the relative lack of homogeneity of each relative to metal or pre-stressed concrete.

Wind on flat surfaces

Previous editions had applied only half the wind loading to the back side of a tower; the 1977 Edition required the full loading on both sides.

1973/1977 Part 3 for Underground Lines and Equipment

The previous Part 3 applicable to premises wiring systems was removed from the NESC in 1970. The Part 3 number was reused in the 1973 Edition for the extensive revision and expansion of the Underground Rules of the previous Section 29 of the 6th Edition of 1961. The *grandfather clause* was added to the underground rules in 1973.

New requirements were added for direct-buried cables. Although some of the requirements mirrored the existing ones for cables in conduit, new requirements for the cable itself and new requirements for random lay of cables, when are directly buried without conduit within 12 inches of one another, were added.

In addition stringent specifications for the security of padmounted equipment containing internal exposed parts above 600 V were added.

1977 Part 4 for Work Rules

Part 4 was extensively revised in the 1973 Edition and reprinted in the 1977 Edition. Revisions included significant increases to the minimum approach distances to energize parts required to be met by workers (unless they were protected with electrical insulation). A large portion of the changes were to bring the language into agreement with modern usage of terms, such as typical personnel titles, etc., and to reorganize and reformat areas for greater comprehension.

> *NOTE: The Occupational Safety and Health Act of 1970 created the Occupational Safety and Health Administration. OSHA produced the first Construction Regulations in 1970. Although utility industry and NESC subcommittee members worked with OSHA in considering appropriate requirements, and the Act required use of existing standards where available, OSHA would not wait until all the changes were made in the 1973 NESC work rules. As a result, OSHA and the NESC have been out of step on occasion, principally due to the much faster revision time for the NESC. Most (but not all) states adopt all of the NESC including the work rules, so using the most restrictive requirement of either the OSHA regulations or NESC work rules applicable to the work is appropriate for training utility workers.*

Proactive Work in the 1980s and later Editions

The 1980s were intensive years of overhauling code language and adding specificity to address modern safety issues and opportunities with electric supply and communication utility facilities. Working Groups and Task Forces utilizing industry experts from around the world were set up to address specific issues and that process continues today. As each edition's effort draws to a close, the scope of work for continuing or new Working Groups and Task Forces is prepared to investigate issues and develop solutions for future editions. Many of these efforts result in changes to the next edition, but some take several code cycles to fully develop and implement. For example, the 1980s saw a coordinated review of clearance requirements and over 20 years of accident data that resulted in both a change in the method of specifying clearances and a coordinated set of revised clearances in the 1990 Edition

1981 Edition of the NESC

The 1981 Edition was the first edition to specify an effective (180 days from publication date). This was the first edition to add revision marks (black lines to the left of code language that changed) to help users quickly identify code changes. This was a very useful addition made by the IEEE editorial staff.

Because 1981 was also the first edition in modern times where all Parts of the Code were revised under the same schedule, the application rules of each Part were pulled out to make a new Section 01 at the start of the Code. Section 01 is now where rules specifying the scope, application, and use of the NESC are specified. The Definitions were also moved into a new Section 02, and references to other standards and documents were moved into a new Section 03.

> *NOTE: in recent editions, references that are not directly called out in the code rules were moved to an appendix at the end of the code, in accordance with international convention.*

1981 Grounding

Requirements were added for underground electric supply cables with semi-conducting jackets that were to be treated as a full electrode.

1981 Electric Supply Stations

Illumination requirements were extensively revised and augmented. Rule 127 on *Hazardous Locations* was completely revised and augmented with complementary information using NEC requirements. Rules 180 and 181 for metal-enclosed switchgear and metal-enclosed bus were also extensively revised.

1981 Overhead Lines and Equipment

This edition started the process of making forward looking revisions to the NESC. A variety of Working Groups were established to address critical issues in overhead rules.

Vertical clearances of lines along roadways

In previous editions, lines that were located on road rights-of-way but not overhanging the roadway were required to have normal roadway truck clearances in urban areas, but were allowed to have 2 feet less clearance in rural areas (that clearance still allowed room for the tractors with mower decks or cycle blades to clear the right-of-way). However, as more truck activity began occurring in rural areas, and as more formerly rural areas were becoming urbanized, it was necessary to require normal truck clearances on all areas of the right-of-way where a truck could pull off the road under the line. Thus the former *Rural* category was renamed to be *Roads in rural districts where it is unlikely that vehicles will be crossing under the line*.

> *NOTE: this category has since been allowed to apply to any location along and within the right-of-way not crossing the roadway where it is unlikely that vehicles will be under the line. Distinctions between urban and rural have been removed from the Code.*

Crossing and parallel line clearances

Extensive revisions were made in Rule 233 for clearances at line crossings and clearances between conductors of parallel lines run on separate pole lines. Conductor movement envelopes and clearance envelopes were first developed in this edition.

1984 Edition of the NESC

This edition started in earnest the wholesale review of the complete overhead rules. Critical areas were prioritized for work over the next several editions. In particular, voltage classifications related to clearances and other requirements were analyzed and appropriate changes were started. Many of these would culminate in extensive revisions to clearances in the 1990 Edition, but a major start occurred in 1984. Throughout the 1980s, accident information was reviewed for relevance to clearance and strength requirements.

The 1984 Edition was the first to introduce metric values into the Code.

1984 Electric Supply Stations

Treatment of gaseous hydrogen systems was clarified.

1984 Overhead Lines and Equipment

Previously, there had been a 2-ft. jump in ground clearances from the 750 V to 15 kV group to the 15 kV to 50 kV group. This could not be electrically justified. In essence 34.5/19.9 kV had a 2 ft. greater ground clearance requirement than 24.9/14.4 kV, but the only practical difference between them was less than a half inch of sparkover distance—they were essentially worked the same. After reviewing accident information and technical information, it was concluded that the large additional clearance above 15 kV could not be justified.

At the time, vertical clearances were specified when the conductors were at 60 degrees Fahrenheit, final sag and the specified clearances included the additional sag expected at 120 degrees Fahrenheit or maximum ice loading, whichever was greater. Part of the plan was to specify clearances for all distribution voltages and use voltage adders for transmission and to require the utility to use actual sag of the conductor, rather than some code-assumed sag. This could not occur until 1990, after the personal computers and appropriate software had been perfected, but the voltage issues could be addressed in 1984. The 750 V to 15 kV group was moved to 750 V to 22 kV for two reasons. First, it grouped all distribution voltages up through 34.5/19.9 kV together. Second, it left 28 kV from 22 kV to 50 kV. Using the normal voltage adder used above 50 kV, that resulted in a one foot jump for the 22 kV to 50 kV column of clearances, instead of the previous two-foot jump. The result was that clearances for all voltages above 22 kV-to-ground dropped by one foot and clearances from 15 kV to 22 kV dropped by two feet. Transmission utilities were then allowed to take advantage of the change and allow more current to flow on many lines (increasing current flow increases conductor temperature and, thus, sag). Removing the unjustifiable extra foot of clearance requirement was a serious help to many utilities in meeting increasing demand.

1984 Underground Lines and Equipment

This edition recommended a prominent warning sign on the second door or barrier of padmounted equipment, where practical.

> *NOTE: Since this edition, the ANSI Z535 series of standards relating to safety signs and labels has been issued and sign materials appropriate for the outside of padmounted equipment are readily available. The NESC refers the Code user to the ANSI Z535 standards for information on designing and applying appropriate safety signs on padmounted equipment.*

1984 Work rules

The procedures to be used in de-energizing lines and equipment for work were extensively revised.

1987 Edition of the NESC

The most significant changes in the 1987 Edition were in the overhead rules.

1987 Overhead Lines and Equipment

Clearances above ground

With the availability of the personal computer and relatively accurate calculation methodologies for conductor temperature, the 1987 Edition removed the double counting of the first 1.5 ft. of sag change from the 60 degree F, final sag position to maximum temperature, so that actual sag changes were recognized. This was required for all conductors in the 1990 Edition.

Category 5 of Table 232-1 was revised to recognize that some areas that were primarily accessible to pedestrians only may also have short maintenance or other vehicles in them. The key determinant is that all expected activity in the area must be expected to be 8 ft. or less in height for the category to apply. If riders on horseback or all-terrain vehicles with antenna masts above the 8-ft. level, etc., are expected, this category is not applicable.

1987 Work Rules

The relatively minimal previous set of minimum approach distances to energized parts for communication workers was expanded and made similar to those required of supply workers.

1990 Edition of the NESC

The 1990 Edition revised Rule 013B to clearly specify options for updating existing facilities to meet later edition of the NESC. Emergency options were also revised.

1990 Electric Supply Stations

New requirements were added for short-circuit protection of equipment and cables.

1990 Overhead Lines and Equipment

High-temperature operation of conductors

With the availability of the personal computer and relatively accurate calculation methodologies for conductor temperature, the 1987 Edition removed the double counting of the first 1.5 ft. of sag change from the 60 degree F, final sag position to maximum temperature, so that actual sag changes were recognized. This was required for all conductors in the 1990 Edition.

Overhead clearances

During the 1980s, the Overhead Clearances Subcommittee reviewed the basis for clearances and adjusted them appropriately in the 1990 Edition. Well over 20 years of accident data was reviewed in the process. Most clearances were determined to be well-founded, but some moved higher or lower to meet the coordinated system of clearances shown in the new Appendix A.

Changes in the vertical clearance specification system

In prior editions, vertical clearances had been specified to be required when conductors and cables were at 60 degrees Fahrenheit, final sag. Included in those clearances was a basic sag change of 1.5 ft. to recognize expected sag changes from that condition to either 120 degrees F or the maximum ice condition, whichever controlled. To recognize the greater sag changes in longer spans, an additional 0.1 ft. of vertical clearance was required at 60 degrees F, final sag for every extra 10 ft. of span length beyond the basic span length specified for each loading zone.

It had been recognized in the 1970s that the Code could not continue to include sag changes in the required clearances because new conductors did not always change in sag the same way as older ones. However, actual sag could not be required until calculation methodologies were refined. During the 1980s, personal computers and reliable conductor sag calculation methodologies became available and in use by all sizes of utilities and conversion of the system became practical for the first time in the 1990 Edition. The 1990 Edition removed the included sag change, specified the actual clearances to be achieved when the conductors were at maximum sag due to either ice loading or high-temperature loading, thus requiring utilities to consider that actual sag changes that would occur in operation.

Clearances of crossing lines and parallel lines on different supporting structures

Rule 233 was extensively revised and expanded for clarity

Clearances to buildings and other installations

Rule 234 was also extensively revised and expanded for clarity. The system specifying clearances after horizontal deflection of conductors under wind loading that had been instituted in the 1977 Edition was removed. It was replaced with a coordinated system of both at-rest clearances and wind-displaced clearances.

Grain bin clearances were also added, culminating a decade of working with utilities, farmers, and grain operators to identify all the associated problems and determine practical clearances for utility facilities.

Clearances between conductors and cables on the same pole line

Rule 235 was revised to clearly specify differences in loadings on the upper conductor versus the lower ones to assure that contact between them would be unlikely with differences in temperature or ice loading.

Fiber-optic cables

A new Rule 230F specifies treatment of fiber-optic cables for clearance purposes. This rule is an example of the Code being proactive and adding requirements to recognize emerging changes in available materials and equipment prior to common use.

Clearances of vertical and lateral conductors

Rule 239 was extensively reorganized and re-specified for the first time in modern times to clearly indicate required clearances and/or protection for riser cables and jumpers from line conductors to equipment. For the first time, grounding metallic supply conduits instead of covering them with a nonmetallic covering where they run through the communication space on a pole or the public area at the base of a pole was recognized as a safe alternative.

Overhead strengths and loadings

Overload capacity factors at replacement were revised for wood structures. The overload capacity factor for Grade C vertical loading was increased.

An alternate method of strength requirement calculations was added (the traditional method was removed after several editions).

1990 Underground Lines and Equipment

Cable grounding and bonding requirements were increased for direct-buried cables in random lay.

1990 Work Rules

The work rules were entirely reorganized in 1990. Section 41 now contains requirements for both supply and communication utility employers. Section now applies all supply and communication employees. Section 43 contains the few additional rules that apply only to communication employees. Section 44 contains the additional rules that apply to supply workers working in the supply space.

1993 Edition of the NESC

Monopolar operation of HVDC lines was clearly prohibited, except for emergencies and maintenance.

1993 Electric Supply Stations

Station structures supporting overhead conductors going outside the station are now required to meet the same strengths and loadings rules as required for structures supporting overhead lines.

> *NOTE: Due to (a) the desire for high reliability of stations and (b) the low loads of the short spans involved inside supply stations, the strength of structures in supply stations had never been an issue and the code had never specified strength requirements for station structures. However, some new low-profile designs of takeoff structures using tubular supports instead of latticed tower structures installed to make the stations more visually pleasing were found to be unable to withstand forces generated by longer spans of conductors during storm conditions, the existing requirements for overhead structures were applied—but only to the takeoff structures.*

Rules relating to *hazardous locations*, such as coal piles were extensively revised similar to changes in recent editions of the National Electrical Code NFPA 70.

1993 Overhead Lines and Equipment

This edition started requiring provisions to be able to render inoperable any remote or automatic operation features on transmission line or distribution line switching devices. This edition also allowed communication circuits not directly associated with the operation of supply lines to be located in the supply space, but only if permission is granted and all work is done by personnel qualified to work in the supply space and who use the supply work rules.

Driveway clearances were clarified in 1993.

A coordinating committee of the NESC and NEC developed changes for clearances to buildings so that the two codes would require consistent treatment of through-the-roof masts. In addition, requirements for insulation of service drop cables were revised to recognize modern constructions that were commonly available for use.

This was the first edition to recognize the lack of voltage potential difference between supply neutral conductors and effectively grounded communication messengers located in the supply space and reduce required clearances between them. The neutral can actually be used as a communication messenger, if desired.

1993 Underground Lines and Equipment

Monopolar operation of HVDC systems is prohibited for normal operation but allowed for emergencies and maintenance.

For the first time, Rule 350G requires marking of direct-buried cables.

1993 Work Rules

Employers must now train employees on appropriate dress combinations that are suitable for various kinds of work.

New specifications were added for using or wearing rubber personal protective equipment. Transient overvoltage control is now required when working over 72.5 kV.

Altitude correction factors were revised, as were the minimum approach distances to energized parts. Clear working distances when working on insulators were added. Aerial device testing requirements were also added.

1997 Edition of the NESC

Where safety signs are required by the NESC, references are made to the new ANSI Z535 standards for safety signs and labels. These standards specify safety colors, formats, and required information.

1997 Overhead Lines and Equipment

This edition clearly recognizes that it is not practical to protect structures from contact by out-of-control vehicles that leave the roadway.

Table 232-2 was modified to allow control boxes for equipment to be mounted near ground level, so long as they do not obstruct a walkway or traveled way.

Ungrounded portions of guys, such as an ungrounded span guy between pole-mounted insulating sections, must have the same clearance required for the highest voltage to which they are exposed. This reflects the increased use of guy insulators in lieu of grounding.

Where insulated pad-mount type elbow cable terminations are used on overhead equipment, clearances are allowed to be less than required for exposed energized parts. The lack of conductivity of entirely dielectric fiber-optic cables were also recognized with reduced clearance requirements on pole lines.

Overhead strengths and loadings

The former Grade D (which applied to communication in conditions that would require Grade B for supply) was eliminated. The few differences between D and B were recognized in B.

Communication cables located in the supply space were added to Table 242-1 to determine the appropriate Grade of Construction.

The previous *overload capacity factors* were split into *load factors* for Section 25 and *strength factors* for Section 26 to recognize modern *load and resistance factor design* methodologies in common use by structural engineers.

The extreme wind map of Rule 250C was retained by referencing ASCE Manual 74 after the ASCE 7 extreme wind map moved from the so-called *fastest mile wind speed* (think steady-state storm winds) to 3-second gust wind speeds. A Working Group was set up to develop methods of applying the new 3-second gust wind speed map to utility facilities. Several years were required to develop appropriate gust response factors to recognize the dynamic response of conductors and structures to wind loading and allow use of the new map.

Guys in parking lots were required to be marked for visibility.

1997 Underground Lines and Equipment

Requirements for supply neutral size, communication cable shielding, and frequency of bonding of supply cables and communication cables buried in random lay were increased.

All padmounted equipment must now be locked or otherwise secured—even if in a fenced area.

1997 Work Rules

Part 4 work rules were harmonized with recently issued OSHA regulations in 29 CFR 1910.137 and 1910.269.

Signs used to warn employees of safety issues must now meet ANSI Z535.

Employers must have an *effective* fall protection program. Fall protection rules were extensively revised.

Requirements for working on secondary voltages with rubber gloves were revised and apply at lower voltages.

Electronic displays are allowed for tagging of SCADA-controlled systems instead of physical tags.

2002 Edition of the NESC

2002 Grounding Rules

Rule 094 includes specifications for different kinds of electrodes. This edition clearly allows different dimensions or configurations with a qualified engineering study.

Grounded supply and communication facilities on the same pole are required to be bonded by new Rule 097G. Although this had been common practice, some communication utilities were found to be deleting bonds with the electric grounds to help them locate underground communication lines, thus creating potentially hazardous voltage potentials between grounded items on the same pole.

2002 Electric Supply Stations

Conditions under which materials not directly related to the operation of a station could be stored in an electric supply station were added. These requirements keep the personnel moving such materials in and out safe and keep the energized section of stations safe from such activities.

Duplication of markings of circuits and equipment within the same station were prohibited.

2002 Overhead Lines and Equipment

Overhead clearances

Clearances between poles and fire hydrants were increased from 3 ft. to 4 ft. to recognize the frequent use of gate valve attachments to allow a second fire truck to attach while the first is throwing water.

Poles are now required to be placed behind all types of curbs, including the relatively new residential swale-type curbs.

The 10-year flood level is again allowed to be used for flood water level for over-water clearances for sailboats on rivers. It had been removed in the 1980s when it was discovered that the recession of the 1970s had prevented the federal government from completing the flooding studies in all areas.

Footnote 26 (now Footnote 25) was added to Table 232-1 to specify how to determine appropriate clearances for lines to be built over areas where it is intended to accommodate oversized vehicles.

Table 234-1 was revised to allow lesser clearances above deck railings where direct stairway access to ground is available. Previous rules recognized the need for an erect person to step off a ladder onto a railing or parapet wall around a roof or balcony. Such clearances are not needed where stairs to the ground exist.

New Rules 234C4 and 238E clearly prohibit anything from being installed in the *communication worker safety zone* between the supply and communication spaces, unless it is expressly allowed by specified rules.

New Rule 235H specified clearances between communication facilities when all are located within the communication space.

New Rule 235I specified clearances for antennas and antenna cases in the supply space.

Overhead strengths and loadings

New Rule 250A4 recognized that, given the flexibility of utility structures, the strengths required by these rules are sufficient to respond to earthquake loading.

Icing accretion models are recommended for calculating ice loads on conductors and cables.

Rule 250C was revised with gust response factors to be able to apply the new ASCE 7 3-second gust wind map to utility loadings.

2002 Underground Lines and Equipment

Manholes deeper than 4 feet must now have ladders or other climbing devices.

Direct-buried cables must be separated from gas lines by at least 12 inches.

The same 4-ft. clearance from poles to fire hydrants is now required from padmounted equipment and fire hydrants by new Rule 380D.

2002 Work Rules

Visibly exposed gas or other fuel lines must be protected from torches or open flames during work. Shoring or other methods are required where cave-in hazards exist.

Communication workers repairing lines after storms must treat the lines as energized unless joint-use power lines are de-energized and grounded.

When working above 15 kV phase-to-phase, additional protection such as an insulated bucket or platform must be used.

Phase-to-ground voltage may be used for rubber glove ratings only where there is no phase-to-phase exposure.

2007 Edition of the NESC

New Rule 013C requires use of the current inspection and work rules. New Rule 018 specifies normal rounding requirements for results of calculations, if a more specific rule does not require otherwise. In concert, the overhead clearance rules require rounding up to the same level as used in the rule or table that requires the calculation (inch, tenth of a foot, tenth of a foot, next higher 5 mm increment).

2007 Grounding Rules

Specifications were added for directly-embedded steel poles, if they were to be considered to be a satisfactory grounding electrode.

2007 Overhead Lines and Equipment

Overhead clearances

Requirements for placement of guy insulators used in lieu of grounding a guy were expanded and moved from the strengths and loadings rules to the overhead grounding requirements in Rule 215.

New Rule 230A4 requires the resultants of calculations to be rounded up to the same level as used by the rule or table requiring the calculation (inch, tenth of a foot, tenth of a foot, next higher 5 mm increment).

Category 10 of Table 232-1 now allows lesser clearances in urban areas (formerly only rural areas) where vehicles under the line are unlikely. Switch handles, braces, etc., were added to Table 232-1.

Rule 235G was specifically revised to allow a multiplex cable to be suspended from a neutral bracket, so long as the insulated phases are positioned to be protected from abrasion. The neutral can also be used as a messenger for a mid-span service drop takeoff.

Overhead strengths and loadings

Grade B is now required over water areas requiring crossing permits to limit obstructions to water rescue after major storms.

Extreme wind requirements were simplified in Rule 250C to allow more specific calculations of wind loading for large tower installations, large capacitor banks on poles, etc.

New Rule 250D specifies extreme ice from freezing rain and concurrent wind combinations with a new map. The traditional ice/wind combination of Rule 250B is retained to address icing from other sources (slushy snow, rime ice, hoar frost, etc.).

New Rule 261N addressed the strength of climbing and working steps and platforms.

The distinction between urban and rural was eliminated for Grade N, the lowest grade of construction.

Placement of guy insulator requirements were moved from Rule 279 to Rule 215C and extensively revised and augmented.

2007 Underground Lines and Equipment

Single-duct conduit that is not part of a conduit system (i.e., not associated with a manhole, handhole, or vault) must now meet the requirements of Section 35 for direct-buried cables, instead of Section 32 for conduits.

No structure can be placed above underground cables, including an above-ground swimming pool, unless the cables are protected from associated forces.

2007 Work Rules

Employers must analyze arc exposure of employees and determine appropriate apparel or apparel systems with the required arc thermal performance characteristics.

New Rule 420Q addresses antenna radiation exposure.

When using guided boring or directional drilling systems, existing underground facilities in the path must be exposed.

Minimum approach distances (MADs) were revised for both communication employees and supply employees. Rubber gloves are required when working *within the reach or extended reach* of the minimum approach distances required for supply employees.

Specific requirements for working above 72.5 kV phase-to-phase are specified if the maximum overvoltage factor T has not been determined from engineering analysis. Temporary transient overvoltage devices are allowed to reduce the per-unit overvoltage factor used to determine MADs.

2012 Edition of the NESC

Extensive language revisions to the purpose and scope rules clarify the actual, practical application of the NESC versus the NEC and other standards that have been established since the emergence of the NESC as a national standard. None of the language changes are new requirement, but rather a more complete statement of historical application of the NESC.

2012 Grounding Rules

Clarification of *effective grounding* requirements were made with a new definition in Section 02 of *effectively grounded neutral* and a revised definition of *effectively grounded* that directly indicates that connection to an effectively grounded neutral serves as an effective ground for equipment.

Metal pole diameter and thickness requirements required to consider a directly embedded metal pole as an electrode were removed. The requirement of 5 ft. of bare embedded length remains to assure that contact area will still be appropriate during movement of the pole caused by storm loading.

The conductor size for connection of communication to the supply ground electrode was changed from AWG No. 14 to AWG No. 6 copper, as a result of the smaller wire acting like a fuse during surge events and catching some vinyl siding on fire. No previous problems had occurred with wood siding.

2012 Electric Supply Stations

Rule 110A2 was revised to specify requirements for the option of using solid sections of fences near energized parts when the normal perimeter fence clearance cannot be met. Storing of vehicles in electric supply stations was allowed under specified conditions.

Illumination requirements were simplified.

2012 Overhead Lines and Equipment

Structures must be attended or climbing barriers installed when temporary steps are attached to a structure.

Attachments to structures require permission of the structure owner. Non-utility attachments, such as decorations, now require permission of the occupants of the space as well as the structure owner.

Overhead clearances

Rule 230A4 was revised to clarify rounding requirements when multiple steps are in the calculation.

A new Clearance Zone 4 was added for warm islands between 25 degrees latitude north and 25 degrees latitude south to reflect appropriate temperature differences (and ice, for higher elevations) near the water versus high elevations.

Footnote 16 was added to Table 234-1 (similar to FN 25 of Table 232-1) to specify how to determine appropriate clearances for oversized vehicles, such as fork lifts, on loading docks, parking decks, etc.

Hot tubs (which do not use skimmer poles or rescue poles) are not considered as swimming pools for clearance purposes.

Communication antennas are considered as *equipment* for purposes of Rule 238 and, thus, must be located in either the communication space or the supply space, and not in the communication worker safety zone.

Overhead strengths and loadings

The previous Table 242-2 for communication was merged with Table 242-1 for supply to eliminate confusion as to the required Grade of Construction.

A new Warm Island Loading District was added for warm islands between 25 degrees latitude north and 25 degrees latitude south to reflect appropriate temperature (and ice, for higher elevations) differences near the water versus high elevations.

Rule 235H no longer allows communication utilities to agree to lesser clearances in the communication space without concurrence of the structure owner. There are two primary concerns: interfering with climbing capability and reducing pole strength if holes are too close together.

The traditional strength requirement calculation methodology is no longer allowed; the alternate method became the primary method.

The same cold temperatures used for conductor tension limit calculations for maximum tension must be used for aeolian vibration limit calculations.

New and revised insulator standards were recognized in Section 27.

2012 Underground Lines and Equipment

Ventilation openings in vaults must either be protected by louvers or baffles or the opening must have the same clearance from energized parts as required for a supply station fence in Rule 110A2 and Table 110-1.

Single-duct conduit must meet the same burial depth requirements as direct-buried cables, unless the structural capability of the conduit will protect the cable from surface usage.

Supply cables of 300 V or less is now allowed to have less than 12 inches of clearance from gas lines, steam lines, etc., if (a) an electrical fault will not damage the other lines and (b) the other parties agree.

2012 Work Rules

A detailed arc hazard analysis may be used to determine the effective arc rating of clothing or clothing systems to be worn by employees working above 50 kV, or specified table values must be used. New tables indicate appropriate clothing rating requirements by equipment type and voltage.

Nonlocking snaphooks are now prohibited on climbing belts.

Maximum clearing times allowed for 4, 8, and 12 calorie clothing systems were updated (and generally increased).

The first level supervisor must conduct a job briefing before work and the subjects are specified.

Contact with trucks and other equipment while setting poles is prohibited unless appropriate insulating personal protective equipment is employed.

Minimum approach distances (MADs) were revised based upon recent flashover studies. Engineering analysis may be used to determine appropriate MADs based upon actual conditions; otherwise the table values must be used.

Availability of Older NESC Code Books

The original code books through 1972 were originally reprinted in hardbound archival copies in the 1970s. Although the hardbound books are no longer available, the reprints are now available from IEEE on a compact disc. This CD includes early NBS Circulars and Handbooks, including the originally published Discussions. The 1973 through 2007 NESC code books are available on a separate CD.

Summary

The National Electrical Safety Code is also known as Accredited Standards Committee C2. The NESC Committee is accredited by the American National Standards Institute (ANSI). It applies to the design, construction, operation, and maintenance of electric supply and communication utilities, both public and private, and including electric power, telephone, cable television, railroad power, railroad signal, lighting district, irrigation district, and alternative communication systems, etc. The NESC applies from the generation of power or signals, or acceptance from another entity, through the transmission and distribution systems up to the service point, where the signals or energy are transferred to a premise wiring system at a *service point*. The National Electrical Code NFPA 70 is applicable from the service point throughout the utilization wiring system on the premises.

The Institute of Electrical and Electronics Engineers (IEEE) serves as the Secretariat of the NESC and supports the operation of the NESC Committee and its subcommittees, working groups, and task forces. IEEE also serves as liaison between the NESC and other standards committees to facilitate coordination where appropriate.

Since the appointment of IEEE as the NESC Secretariat, the NESC has been modernized and started operating with a forward view so that changes can be made in a timely fashion. The effectiveness of the National Electrical Safety Code can be seen in electrical accident data. The frequency of accidents of electric supply and communication workers on utility systems is down in both positive numbers and relative numbers. The numbers of public accidents on utility systems of various kinds has leveled off or declined in number on an annual basis and declined relative to miles of line, numbers of customers, kilowatt-hours delivered, etc. While some of the decline is directly attributable to the application of OSHA regulations in the workplace, a large portion of the decline is attributable to the improved specification of NESC requirements and dramatic increase in knowledge of NESC requirements by utilities since IEEE took over as the Secretariat in 1972.

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Allen Clapp is a past Member (1973-2008; Chair 1984-1993) of the National Electrical Safety Code (NESC) Committee and is Editor of the NESC Handbook. He served on the following NESC Subcommittees:

- National Electrical Safety Code Executive Subcommittee 1976-1993 (Chair 1984-93)
- Interpretations Committee 1976-present (Chair 1981-1990)
- Coordination Subcommittee 1978-2012 (Secretary 1981-84, Chair 1993-2012)
- Clearances Subcommittee 1971-present (Acting Secretary over 20 times)
- Strengths and Loadings Subcommittee 1971-present (Secretary 1978-2010)

Mr. Clapp is President of the Power & Communication Utility Training Center and President of Clapp Research Associates, PC. He has instructed over 25,000 utility personnel in NESC requirements since 1976. He has served over 500 utilities in the United States and abroad in his consulting efforts. He has investigated over 800 utility-related accidents.