ELECTRICAL INSTALLATION REQUIREMENTS

A Global Perspective

National Electrical Manufacturers Association

By Underwriters Laboratories Inc.
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FOREWORD

This study was undertaken as part of the NEMA Global Strategy Initiative. Increased sales and use of electrical products in markets around the globe make it imperative that manufacturers, codes and standards developers, and conformance assessment organizations have a clear understanding of the electrical installation systems in which electrical products are being used. The intent of this document is to foster a better understanding of the similarities and differences between the National Fire Protection Association's NFPA 70, *National Electrical Code,®* and the wiring rules promulgated by IEC 60364, Electrical Installations for Buildings. These two prominent documents collectively serve as the basis for electrical wiring used in over 90 percent of the world.

The extensive document comparison and analysis in this report was conducted by Underwriters Laboratories under contract to NEMA. Funders include NEMA, NIST, NFPA, and UL. The IEC covered the expenses of David Latimer, IEC TC64 Chairman. The effort was reviewed and critiqued periodically during the process by a Peer Review Committee convened expressly for this task. The professional standing of committee members made them particularly well suited for this assignment. Committee members included Paul Duks, Underwriters Laboratory; Mark Earley, NFPA; Ken Gettman, NEMA; David Latimer, IEC TC64 Chairman; Francois Martzloff, NIST; John Minick, NEMA; Bob McCullough, IAEI, Ocean County Construction Inspection Department; George Ockuly, Cooper Bussmann; Jim Pauley, Schneider Electric; Jack Wells, Pass & Seymour Legrand; and John Young, Siemens.

This report reflects the contributions of committee members, all of whom believed in the important implications that the analysis will have for the electroindustry here and abroad. David Latimer offers the following insights into the work of the committee:

> *"I have been pleased to take part in the peer review group that assisted in the preparation of this report; my contribution has been to further the understanding of IEC 60364."*
>
> *"The reference in the Assessment of Style Attributes section to IEC 60364 as not being intended as a document for use by engineers and electricians is mine. Almost all countries that have adopted IEC 60364 as the basis for national standards provide guidance either produced by themselves or another country, but not all."*
>
> *"The guidance can be divided into two classes, one of which is broad guidance, expanding upon the principle, and for the assistance of the senior designer engaged in large or difficult installations. The other is 'do it this way' guidance. The NEC is a 'do it this way' document. It has a broad scope and covers the widest possible range of situations. I believe that installations carried out to the NEC will comply with the requirements of IEC 60364. Without doubt, they comply with Chapter 13."*
>
> *"I do not believe that the NEC is suited to be, nor could it become, an international standard. What it is suited for and could be declared to be is a way of making an installation which complies with IEC 60364 when using equipment listed in UL or U.S. standards."*
>
> *"The point is made in the report that because of the limited experience of national committees and delegates to TC 64 in 110 volt systems, the requirements of IEC 60364 do not fully reflect the needs of such systems. This may possibly be so. I would welcome an indication of the way in which IEC 60364 might be amended to meet these needs, thus enabling IEC 60364 to be adopted by ANSI as a U.S. standard, with the NEC as a 'means to comply' document for those countries that wish to use it."*

The work summarized in this report is the beginning of a more extensive effort by NEMA member companies. NEMA product technical sections are planning to use this report as a reference document and a roadmap to improve their understanding of the commercial applicability of their products in the installed electrical infrastructure in target countries or regions utilizing the wiring principles of IEC 60364. Some NEMA sections may choose to simply take note of the differences between the two subject wiring approaches; others will pursue a strategy to make changes in one or both code documents in an attempt to broaden the market applicability of their products.

ACRONYMS & ELECTRICAL CIRCUIT DESIGNATIONS USED IN THIS REPORT

ANSI American National Standards Institute
AWG American Wire Gauge
ELV Extra-low voltage circuit
- **FELV** Functionally grounded (earthed) extra-low voltage circuit, which may or may not be separated from higher voltage circuits
- **PELV** Protectively grounded (earthed) extra-low voltage circuit, which is separated from higher voltage circuits
- **SELV** Extra-low voltage circuit that is isolated from higher voltage parts and from grounded (earthed) parts

EMC Electromagnetic compatibility
EMI Electromagnetic interference
EU European Union
GFCI Ground-fault circuit-interrupter
IEC International Electrotechnical Commission
ISO International Organization on Standardization
IT Ungrounded (isolated) electrical supply system with or without a distributed neutral. Equipment is grounded (earthed)
ITE Information technology equipment
NEC *National Electrical Code*
NEMA National Electrical Manufacturers Association
NFPA National Fire Protection Association
PE Protective earthed conductor (equipment grounding conductor)
PEN Protective earthed neutral conductor (also serves as an equipment grounding conductor)
RCD Residual current device (senses and responds to interrupt the circuit on ground faults)
TN A neutral grounded (earthed) electrical supply system
TNC A neutral grounded (earthed) electrical supply system where the neutral serves as the protective conductor, i.e. PEN conductor
TNCS A neutral grounded (earthed) electrical supply system where, in part of the installation, a PEN conductor is used and in other parts a separate PE conductor is used
TNS A neutral grounded (earthed) electrical supply system with separate neutral and protective earthed (PE) conductors
TT A neutral grounded (earthed) electrical supply system where the source neutral and the electrical equipment are grounded (earthed) separately (earth serves as the return path for leakage and fault currents)

EXECUTIVE SUMMARY

This document explores the similarities, differences, and various attributes of two documents: the *National Electrical Code,®* ANSI/NFPA 70, and the International Electrotechnical Commission Standard, IEC 60364, *Electrical Installations of Buildings.* These documents serve as a basis for national wiring rules throughout the world.

The review was undertaken to gain an understanding of the two codes or standards, and to record their usability, adoptability, and practicality. The information herein may be considered by various officials and decision-makers around the globe embarking on development or adoption of national electrical installation requirements. NEMA sections plan to use this report as both a reference document and as a roadmap to improve their understanding of the commercial applicability of their products with regard to the installed electrical infrastructure in target countries or regions. Some NEMA sections may choose to simply make note of the differences between these two wiring approaches, while other sections will pursue a more proactive strategy and work to make changes in one or both code documents to broaden the market applicability of their products. This work is just getting underway.

In general, the review shows that the documents are different and were developed with different purposes in mind. While the *NEC* evolved along with the growth of electrical systems in North America more than 100 years ago in order to establish a uniform level of safety, the development of IEC 60364 documents ensued in 1969 for reasons of harmonization of electrical installation rules to facilitate trade among European countries.

IEC 60364 is a collection of documents that define fundamental principles, practices, and performance requirements which reflect the European concept of wiring and distribution systems. The *NEC* is a set of specific rules intended to be used for design, installation, and uniform enforcement of electrical system installations based on North American principles and practices.

To be effective, an electrical installation code must be suitable for the existing electrical infrastructure, be suitable for the electrical safety system employed in a country, and be capable of being uniformly interpreted, applied, and enforced. It must also have compatibility with standards applicable to products whose installation, use, and maintenance is intended to be governed by the code.

In summary, the following can be stated about the documents:

- IEC 60364 and the *NEC* both establish performance requirements that address fire and electric shock protection, i.e. protection of persons and property.
- Both documents address installation, use, and maintenance of premises wiring systems and equipment.
- Both documents are applicable to wiring systems of premises for residential, commercial, and industrial use. Hazardous locations (explosive atmospheres) are covered only in the *NEC;* they are covered separately in IEC 60079.
- Neither document covers installations for generation, transmission, or distribution of electrical energy, nor those under exclusive control of electric or communications utilities.
- IEC 60364 provides broad performance requirements and it is not usable as an installation document by electrical system designers, installers, or enforcing authorities, but rather it can serve as a guide for development of national wiring rules.
- The *NEC* is a comprehensive set of electrical installation requirements that can be adopted and implemented without development of additional wiring rules.
- Countries adopting IEC 60364 in whole, or only Chapter 13 on Fundamental Principles, need to develop additional rules usable by electrical system designers, installers, and enforcing authorities.
- Both codes need effective coordination with appropriate product standards to be successful in implementing electrical safety.

INTRODUCTION

The IEC 60364 standard, "Electrical Installations of Buildings," is copyrighted by the International Electrotechnical Commission, although the right of reproduction and distribution in any country lies with the national committee of that country. In the U.S., ANSI holds the rights for distribution of IEC standards. The "*National Electrical Code*" and "*NEC*" are registered trademarks of the National Fire Protection Association.

The review of the above two documents covers:

- Overall assessment of both documents
- Suitability for adoption
- Effect of normative references
- Assessment of style and attributes
- Comparison of significant provisions (*NEC* to IEC 60364) and cross-references (IEC 60364 to *NEC*)

Additional information is contained in Annexes A-1 through F:

- Annex A-1 contains a presentation of the layout and arrangement of the *National Electrical Code*.
- Annex A-2 depicts the numbering system and plan of IEC 60364.
- Annex B-1 contains normative references found in IEC 60364. (Only one location for the referenced documents is indicated; cross-references to other parts of IEC 60364 are not indicated in this tabulation.)
- Annex B-2 contains identification of U.S. product safety requirements corresponding to the normative references tabulated in Annex B-1.
- Annex C contains excerpts from ISO/IEC Directives, Part 3, 1997, on verbal forms of expression for provisions, and on notes and examples integrated in the text.
- Annex D illustrates two typical circuits of U.S. installations. These circuits were analyzed for compliance with IEC 60364 provisions.
- Annex E contains an analysis of the allowable ampacities of the two documents.
- Annex F depicts time/current characteristics of some fuses and circuit breakers.

In this report, the 1999 edition of the *National Electrical Code* was used. IEC 60364 documents available as of May 1, 1998, were used; the issue dates of the documents are indicated in cross-references, IEC 60364 to *NEC*, of this report.

OVERALL ASSESSMENT

The National Electrical Code

General—The U.S. *National Electrical Code* is over 100 years old. The *Code* was established at the beginning of the growth of distribution systems for electrical energy and its use for lighting and driving machinery. It is a cohesive and comprehensive document that is revised on a three-year cycle. It is a model code intended for legal adoption or reference by countries, states, counties, cities, and other municipalities, with or without amendments. It is written in mandatory language and it is suitable for use by designers, engineers, and installers, as well as for mandatory enforcement by verification bodies. The *NEC* is adopted and used in various jurisdictions of the United States and in a number of other countries. It has been translated in Japanese, Korean, and Spanish. The *NEC* can be characterized as containing performance criteria and acceptable solutions, and it is written to facilitate verification to ensure that effective levels of safety have been achieved. The prescriptive requirements contain acceptable solutions.

Relationship with Product Standards—Even though there are no normative (mandatory) references in the *NEC*, there is a close relationship with and reliance on provisions in product standards. The *Code* rules take into consideration known performance capabilities and required construction features of electrical construction materials and utilization equipment. In the converse, electrical products must be evaluated and certified not only for risks to life and property, but also for potential conformity to the installation and use provisions of the *NEC*. Whenever the *NEC* is revised, product safety standards must be reviewed and revised when necessary to maintain continued compatibility. The *NEC* covers electrical installations from the service point to the outlets and it includes some requirements for utilization equipment. The *Code* also covers installations in hazardous locations (explosive atmospheres).

Organization, Layout, and Content—In general, the *NEC* is organized to address parts of electrical installation. The *Code* consists of an introduction and nine chapters. Chapters 1 through 8 contain articles. Introduction is article 90. Chapter 9 contains tables. Text is in sections, the numbers for which include the article designation, e.g. section 110-3. Chapters 1 through 4 of the *Code* apply generally; Chapters 5, 6, and 7 apply to special occupancies, special equipment, or other special conditions. These latter chapters supplement or modify the general rules. Chapters 1 through 4 apply, except as amended by Chapters 5, 6, and 7 for the particular conditions. Chapter 8 covers communications systems and is independent of the other chapters, except where they are specifically referenced therein.

The provisions of the *NEC* cover specific requirements for installation, use, and maintenance of electrical systems in various types of premises, other than those under the exclusive control of electric or communications utilities, and as stated in Section 90-2(b) of the *NEC*. The rules also address certain features of utilization (current-using) equipment. This ensures that proper overcurrent protection and other safety features are provided on the equipment. The equipment must be suitable for the circuit to which it is connected. Likewise, the circuit must be capable of supplying the particular connected load(s) without risks to life and property.

IEC 60364

General—The standard, *Electrical Installations of Buildings*, IEC 60364, was developed by the International Electrotechnical Commission with headquarters in Geneva, Switzerland. This document is intended to serve as a basis for development of national requirements. Development of electrical installation requirements in several European countries started about the same time as the *National Electrical Code*. Because the European countries are in close proximity to each other, harmonization of electrical installation requirements became desirable. In 1969, a number of European countries embarked on an effort to harmonize their respective national wiring practices. The multitude of differences rendered this effort unsuccessful. Agreement on a complete set of wiring rules could not be achieved. However, it was determined that a document defining fire and life safety principles and objectives was feasible. These principles then could serve as the basis on which national wiring practices could be developed. The effort was refocused on this objective and development of IEC 60364 documents ensued, using Chapter 13 of Part 1 as the cornerstone.

The note to Chapter 13, which covers fundamental principles, indicates that:

> "Where countries not yet having national regulations for electrical installations deem it necessary to establish legal requirements for this purpose, it is recommended that such requirements be limited to fundamental principles which are not subject to frequent modification on account of technical development. The contents of Chapter 13 may be used as a basis for such legislation."

The fundamental principles cover the need for protection against various hazards that may occur due to the use of electricity. IEC 60364 is broadly performance-based and is not intended to be used directly by designers, installers, or verification bodies, but rather for use as a guide for development of national wiring rules.

Organization, Layout, and Content—IEC 60364 is an assembly of 38 separate documents and 10 amendments of various publication dates. A number of provisions in the documents are incomplete, i.e. they are indicated as being under consideration. Some of the documents have not been revised since they were issued, as early as 1977.

The IEC 60364 documents cover electrical installations from the service entrance, but stop at the outlets for current-using equipment. Installations in hazardous locations (explosive atmospheres) are covered in separate IEC 60079 documents. Also, IEC 60364 limits its scope to installations of circuits up to 1000 V, whereas the *NEC* does not contain a specific voltage limitation for premises installations. This lack of rules for higher voltages could be a serious consideration for high-rise building installations.

The fundamental principles contained in Chapter 13 of Part 1 encompass protection for safety: electric shock, thermal effects, overcurrent, fault currents, and overvoltage; as well as design, selection of electrical equipment, and erection and initial verification of electrical installations. These basic principles cover hazards known by trained persons to be associated with the use of electricity. Knowledge of the involved hazards and statements for the need of protection against such hazards may not be sufficient for guarding persons and property without more specific rules on how the protection is to be accomplished. Other parts of IEC 60364 deal with conditions which may introduce hazards and measures of protection to be provided. Some provisions are advisory or contain recommendations. Time and resources would be required if documents were to be used to develop a national electrical installation code suitable for uniform application.

The numbering system and plan of IEC 60364 are indicated in Annex A to Part 1 of IEC 60364. The numbering system and updated plan are contained in Annex A-2 of this report. In general, it can be stated that IEC 60364 documents are organized by function. Part 1 contains the scope, object, and fundamental principles. Part 2 contains definitions. Part 3 deals with assessment of general characteristics, such as purposes, supplies, and structure, classification of external influences, compatibility, maintainability, and safety services. Part 4 addresses protection for safety. The hazards that are being addressed are electric shock (direct and indirect contact), thermal effects, overcurrent for conductors and cables, overvoltage, undervoltage, isolation, and switching, application of protective measures for safety, and choices of protective measures as function of external influences. Part 5 deals with selection and erection of electrical equipment. It contains common rules, addresses wiring systems, switchgear, and controlgear, earthing arrangements and protective conductors, other equipment, and safety services. Part 6 covers verification, and Part 7 addresses requirements for special installations or locations, such as bathrooms, swimming pools, sauna heaters, construction sites, agricultural and horticultural premises, restrictive conducting locations, earthing requirements for installation of data processing equipment, electrical installations in caravan parks and caravans, electrical installations in marinas and pleasure craft, medical locations and associated areas, and electrical installations in exhibitions, shows, stands, and fun fairs.

Example—The difficulty in using the IEC 60364 documents for direct application to an installation can be best illustrated by example. The statements covering overcurrent protection, permitted type and location of disconnect means, and other rules concerning installation of appliances, are located throughout the documents and may be subject to choice and interpretation. For instance, on overcurrent protection, the section on Protection for Safety has Clause 131.4 covering protection against overcurrent. Section 132 on Design has Clause 132.8 on protective equipment, wherein the characteristics of protective equipment shall be determined with respect to their function for which the equipment provides protection. Among the effects against which protection needs to be provided are overcurrent (overload, short-circuit) and earth-fault current. Then, Part 4, which covers Protection for Safety, has Chapter 43, Protection Against Overcurrent. This chapter includes general statements on the nature of protective devices; protection against overload current, protection against short-circuit current, and coordination of overload and short-circuit protection. The chapter was issued in 1977, but contains Amendment No. 1, which deletes references to some outdated fuse types. Protection requirements are expressed in formulas and deal mainly with protection of conductors. Since the IEC 60364 rules stop at the socket outlet, overcurrent protection for current-using equipment is not addressed. Typically, electrical equipment is designed for connection to circuits provided with a specific rating(s) and type(s) of overcurrent device. Lack of code rules on safety features for electrical equipment could result in inappropriate or hazardous installations. In addition to the foregoing there is Section 473 on Measures of Protection Against Overcurrent. Certain aspects of overcurrent protection are treated in a number of separate sections.

In a similar manner, Chapter 46 covers Isolation and Switching, while Section 537 covers Devices for Isolation and Switching. Rules which cover one safety feature are located in different parts of the documents.

Existing Infrastructures

A significant difference in electrical system characteristics that has influenced electrical safety rules is the difference in voltage for the majority of utilization circuits. In North America and a number of other countries, typical household and other general purpose receptacle circuits operate at 120 V, ac. In European countries and some other parts of the world, 240 V, ac, (between conductors and to ground) is the norm. The higher voltage makes it easier to disconnect earth faults in TN systems without use of residual current devices (RCDs). However, the higher circuit voltage can create higher touch voltages. Together with the permitted variations in supply system grounding (earthing) rules, a necessity is created to devote more attention to prevention of shock hazards due to indirect contact (with accessible parts that may become live due to a fault).

One important consideration in development of new national electrical installation requirements, is the type of existing infrastructure and electrical supply systems. In areas where the general purpose utilization circuits operate at 120 V, ac, the *NEC* may be more appropriate. Even if these circuits operate at 240 V and the supply systems are of TNS or TNCS type, the *NEC* could be applied with modifications to some parts of the *Code*, mainly in Article 210 sections on branch circuit voltages. The *Code* also accommodates IT and TNC systems. In the event the existing branch circuit conductors have metric dimensions and the common conductor sizes and overcurrent device ratings of the IEC standards are employed, some adjustments in the *NEC* would be necessary, mostly for unit conversions. However, from the standpoint of uniform application and enforcement, the *NEC*, with its comprehensive requirements, would be a more appropriate base document for development of national wiring rules. Countries with IT, TNC, TNS, and TNCS systems could adopt Chapter 13 on fundamental principles as the guiding principles and adopt the *NEC* as the national installation and wiring rules, or they could use IEC 60364 as a basis for development of their national rules.

In areas of the world where TT premises wiring systems exist, the IEC 60364 documents may be more suitable for promulgating national wiring rules. The *NEC* specifically prohibits TT supply systems. The IEC 60364 documents contain the requirements for the additional safety features, which are necessary for TT supply systems.

Emphasis on Safety Rules

The *National Electrical Code* Committee members have been influenced by the building construction features prevalent in North America which, for residential and small commercial use, are typically wood frame type. On the other hand, members of TC64 who, in the majority, are representatives of European countries, are more familiar with characteristics and performance of masonry buildings. Historically, this difference influenced the emphasis on the need for protective features. Many installation rules in the *NEC* address protection against fire. This is evident from the rules for overcurrent protection, effective fault current return path to the source, somewhat conservative rules for sizing of conductors (Sec. 310-15), and grounding of the supply circuit. This is not to say that the *NEC* is lacking in rules for shock hazard protection. Rules on grounding and bonding, effective ground return path, provision of enclosures, requirements for working space about electrical equipment, for instance, address risks of electric shock. Also, in locations where there have been indications of increased risk of electric shock, low trip-level personnel protective devices (GFCIs) are required.

Even though IEC 60364 rules emphasize shock hazard protection, there are adequate provisions for protection against fire hazards. The residual current devices were initially developed to mitigate fire hazards due to ground fault currents; presently, however, IEC 60364 documents include requirements for 30 milliamp trip-level RCDs only in relation to shock hazard. RCDs with other ratings may be used to achieve the disconnecting times during earth-fault conditions. Undeniably, if an installation includes an RCD, it can also mitigate fire hazards caused by ground fault conditions.

In the past, the type of building construction may have influenced the emphasis on the characteristics of protective measures that may be required. The present sets of rules in both publications adequately address the hazards associated with the use of electricity for both types of building construction.

SUITABILITY FOR ADOPTION

The *National Electrical Code* is a model code written to be suitable for adoption and use with few local deviations, if any, or development of any supplemental rules. It is written in mandatory language and does not contain any recommendations. The *NEC* does contain "Fine Print Notes" which are explanatory in nature. They may contain references to other documents, although compliance with the other documents is not mandatory. The *Code* is a set of requirements, the compliance with which provides for practical safeguarding of persons and property from hazards arising from the use of electricity. It is suitable for adoption and implementation without (or with) modification or additional rules. It is kept current with the state of technology on a regular three-year cycle. Because of its mandatory language, it facilitates uniform application and enforcement.

The IEC 60364 standard on *Electrical Installations of Buildings* is intended to serve as a model for development of national requirements. It has been characterized as not being suitable for direct adoption as an installation practice. Due to its composition, layout, and inclusion of recommendatory and advisory provisions, effort is needed to create documents that include mandatory installation language which can be uniformly applied.

The method of implementation of IEC 60364 documents can be illustrated by the process taking place in the UK. There is an IEC 60364-based European document, HD 60384. In Britain, the HD 60384 document would have been used to develop the British "Requirements for Electrical Installations," BS7671. In addition, in Britain the Institution of Electrical Engineers developed an IEE On-Site Guide to BS7671. The On-Site Guide is the document that is actually used by installers and verifiers for domestic installations and associated buildings, as well as for industrial and commercial single- and three-phase installations where the single-phase voltage is 230 V, ac, and the three-phase voltage is 230/400 V, ac, with service at 100 A or less. The guide indicates that installations made in accordance with its guidelines will meet BS7671. For installations other than those indicated above, BS7671 must be utilized.

Countries that have based their wiring rules on IEC 60364 probably had to go through a similar process and produce an installation guide or practice for use by designers, installers, and verification bodies.

EFFECT OF NORMATIVE REFERENCES

The *National Electrical Code* does not contain any normative references to other documents. There are some explanatory notes which refer to documents for a method of ascertaining certain characteristics or performance capabilities. Where the *NEC* is used, product norms in concert with the *Code* must be developed. There must be a close relationship between the provisions in product standards and the *Code* rules to provide an effective safety system. The *Code* rules must take into consideration known performance capabilities and required construction features of electrical construction materials and utilization equipment, as defined in the product standards.

IEC 60364 documents contain numerous normative references. There are two references to ISO documents and 72 to IEC documents, many in a number of locations (see Annex B-1 of this report). Where a national document would be based on IEC 60364 provisions, the normative references to IEC standards would be replaced by references to national standards, if such exist. With normative references, the national standards then form part of the installation code. This and the methods for confirming compliance with the referenced standards need to be considered when a baseline document is chosen for development of national wiring rules.

ASSESSMENT OF STYLE AND ATTRIBUTES

This tabulation contains a comparison of various aspects of style and attributes of the two documents. Both the IEC 60364 and the *National Electrical Code* are intended to serve as a basis for national or local requirements. However, one of the major differences between the documents is that the *NEC* can be adopted with few local deviations or additions, but IEC 60364 can only serve as a guide for development of a document that would be useable to achieve equally safe installations and which could be uniformly applied. Significant technical differences between the two codes are highlighted under Comparison of Significant Provisions, *NEC* to IEC 60364.

IEC 60364	***National Electrical Code, NFPA 70***
<u>Plan or Arrangement and Numbering System</u>	
60364-1, Annex A: Divided into seven parts. Each part (except Part 7) is divided into chapters. Chapters may be divided into sections. Text is in clauses or sub-clauses, e.g. 442.2.	90-3: Divided into Introduction and nine chapters. Chapters 1 through 8 contain articles. Introduction is Article 90. Chapter 9 contains tables. Text is in sections, the numbers for which include the article designation, e.g. Sec. 110-3.
<u>Referenced Documents</u>	
Normative references: "The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60364," e.g. Clause 3.2.	No normative or mandatory references are in the *NEC*. However, some equipment is specifically required to be listed (certified), which by definition means that the equipment "…meets appropriate designated standards…"
Informative references: Intended for information only.	U.S. product requirements comparable to those of the normative references in Annex B-1 are indicated in Annex B-2 of this report. See Sec. 90-7.
Notes associated with text are not to contain provisions necessary to claim compliance with the document. However, some notes contain mandatory text, e.g. Note 1 to 411.1.1. A number of notes contain recommendations.	"Fine Print Notes": Explanatory notes that may contain references to other documents. Not mandatory. Sec. 90-5.
According to ISO/IEC Directives, Part 3, 1997, there are three types of technical reports which are informative in nature and which may be referenced in IEC documents: Type 1 Technical Report: Publication for	The National Fire Protection Association also produces and publishes a *National Electrical Code* Handbook for each edition of the *Code*. This publication contains the text of the *NEC* with interspersed informational explanations. This is an unofficial publication intended only to assist users of the *NEC* in proper

IEC 60364	*National Electrical Code, NFPA 70*
which the required support for approval as an international standard cannot be obtained, or for which there is doubt on whether consensus has been achieved. Type 2 Technical Report: Publication of work still under technical development, or where for any other reason there is the future, but not immediate, possibility of agreement on an International Standard. Type 3 Technical Report: Informative publication containing collected data of a different kind from that which is normally published as an international standard.	interpretations. Only the text of the *NEC* contained in the handbook has been subjected to the consensus process. The explanatory material is developed by editors and voluntary sources. In the U.S. there are also a number of private *NEC* handbooks, which are directed at various segments of the electrical industry.
Amendments	
Amendments are issued on a continual basis, as developed. Applies also to documents in normative references. In accordance with ISO/IEC directives, the technical committees decide at what intervals a standard should be confirmed, revised, or withdrawn (see Administrative Circular, 53/AC, 1998-03-20).	New editions are issued every three years. Tentative interim amendments are adopted only on basis of emergency to correct gross error, avert hazardous installations, or to recognize an advance in the art of protecting life or property (only two TIAs to the 1996 *NEC*).
Proposals for Amendments	
National committees and member bodies submit proposals for amendments to the appropriate technical committee.	Any organization or individual from the U.S. or any country of the world may submit proposals for amendments to the NFPA.
Evaluation of Proposed Amendments	
Proposed amendments are first evaluated by TC64 task groups. Final acceptance is by the responsible technical committee, TC64, via ballots. One country, one vote. 28 “P” (voting) members. A 2/3 affirmative vote by “P” members, and less than 1/4 of “P” and “O” (observer) members in opposition is needed to pass a proposal. Interest representation (manufacturer, installer, designer, enforcer, etc.) not specified.	By one of 20 code-making panels which have balanced interest representation such as manufacturers, users, installers, verification bodies, research/testing, utilities (public suppliers), labor, and others. A 2/3 affirmative vote is needed to change the *Code*. All actions are reviewed by Technical Correlating Committee. The standards making procedures are covered in NFPA’s Regulations Governing Committee Projects.
Publication Time Period	

IEC 60364	*National Electrical Code, NFPA 70*
Approximately two months after final voting period.	Approximately three months after issuance of the new edition by the NFPA Standards Council.
Cost	
IEC 60364 documents only (no normative references), single copy: $1900.00 U.S. For hazardous locations (explosive atmospheres), add IEC 60079 for an additional $1784.00 U.S.. National standards based on IEC 60364 cost considerably less. For instance, in the U.K., the BS7671 *Requirements for Electrical Installations* costs $70.00 U.S.	Single copy (1999 Edition): $42.00 U.S. for members of NFPA; $46.75 U.S. for nonmembers. Includes hazardous locations (explosive atmospheres) installation requirements. English. Spanish language edition — same as above.
Languages	
English and French in each document.	English and Spanish in separate books.
Adoption by Authorities	
IEC 60364-1, Chapter 13, Fundamental Principles, NOTE: Where countries not yet having national regulations for electrical installations deem it necessary to establish legal requirements for this purpose, it is recommended that such requirements be limited to fundamental principles which are not subject to frequent modification on account of technical development. The contents of Chapter 13 may be used as a basis for such legislation.	Inside back cover of *NEC* book: Licensing Provision—This document is copyrighted by the National Fire Protection Association (NFPA). 1. Adoption by Reference: Public authorities and others are urged to reference this document in laws, ordinances, regulations, administrative orders, or similar instruments. Any deletions, additions, and changes desired by the adopting authority must be noted separately. Those using this method are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. The term “adoption by reference” means the citing of title and publishing information only. 2. Adoption by Transcription: Public authorities with lawmaking or rulemaking powers only, upon written notice to the NFPA (Attention: Secretary, Standards Council), will be granted a royalty-free license to print and republish this document in whole or in part, with changes and additions, if any, noted separately, in laws, ordinances, regulations, administrative orders, or similar instruments having the force of law, provided that: (states conditions for license). Some states, counties, cities or other municipalities adopt the *NEC* with or without deviations by one of

IEC 60364	*National Electrical Code, NFPA 70*
	the above methods. Some entities in the U.S. develop their own electrical installation codes.

Coverage of Electrical System

IEC 60364	*National Electrical Code, NFPA 70*
Includes provisions from the point of supply for a building to the socket outlets. Does not include rules for appliances or other current-using equipment. Does not include rules for installations in explosive atmospheres.	Includes provisions from the service point of a premises to branch circuit outlets. Includes rules for appliances and other utilization equipment, which may affect selection or protection of electrical system components or other aspects of safety. Includes rules for hazardous (classified) locations [explosive atmospheres]. Rules in Art. 505 are harmonized with IEC 60079.

Equipment Approval

IEC 60364	*National Electrical Code, NFPA 70*
"Every item of equipment shall comply with such IEC Standards as are appropriate and, in addition, with any applicable standards of the ISO" (511.1). Verification is to be by visual inspection. No other method for verification of conformance is indicated.	The conductors and equipment required or permitted by the *Code* shall be acceptable only if approved (110-2). Suitability of equipment may be evidenced by listing or labeling by a qualified electrical testing organization.

Verification of Compliance

IEC 60364	*National Electrical Code, NFPA 70*
By authorities and verification methods under the rules or regulations existing in countries, provinces, or localities where the document is adopted by law or regulation.	By authorities and verification methods under the rules or regulations existing in countries, provinces or localities where the document is adopted by law or regulation.

Layout of Subject Matter

IEC 60364	*National Electrical Code, NFPA 70*
Fundamental requirements for safety (Part 1); assessment of general characteristics (Part 3); essential requirements for protection persons, livestock, and property (Part 4); selection and erection of equipment (Part 5) are in separate documents. Requirements from all the foregoing need to be brought together to assess a particular installation (see Annex A-2 of this Report for the numbering system and plan of IEC 60364).	Layout of subject matter is equipment or installation method oriented, and it is organized by parts of the installation (see Annex A-1 of this Report).

Suitability for Enforcement

IEC 60364: Contains mandatory requirements characterized by "shall" or "shall not" and includes recommendations. Need for compliance with some provisions can be agreed upon by the installer and the owner or specifier. Also contains design guidance, which is typically considered by verification bodies to be outside of an installation code.
IEC 60364 has been characterized as "…not yet finished…" and that it "…is not a document to be used directly by designers or electricians; it is intended to be the document upon which countries base their document."

National Electrical Code, NFPA 70: Contains mandatory requirements characterized by "shall" or "shall not." No recommendations. Fine Print Notes contain only explanations. No design guidance, per Sec. 90-2. Suitable for adoption, use by designers, engineers, and installers, and for mandatory enforcement by verification bodies.

Coded External Influences

IEC 60364: Parts 3 and 5 contain extensive lists of coded external influences and severity levels. However, there is no indication whether equipment is marked to indicate that it is designed for the particular external influences and severity levels. In fact, some conflicting coding exists. In Sec. 321, the code AC2 signifies altitudes higher than 2000 m above sea level. In IEC 60947-1 on Low-Voltage Switchgear and Controlgear, Annex A indicates utilization categories where AC2 signifies starting and switching off slip-ring motors. Confusion may result.

National Electrical Code, NFPA 70: Published certification information and product markings indicate environments, conditions, and uses for which the equipment has been evaluated. In conjunction with Sec. 110-3, safe installations are achievable. Further, Table 430-91 contains type designations which indicate the environmental conditions against which a degree of protection is provided by motor controller enclosures. A similar table appears in product certification information for other electrical equipment.

COMPARISON OF SIGNIFICANT PROVISIONS, *NEC* TO IEC 60364

The text under each of the following headings identifies the location of the requirements with a brief statement on the subject matter. Most sections of the *NEC* were analyzed and corresponding or related requirements or definitions in IEC 60364 are indicated. Where a specific feature was not covered in IEC 60364, such an absence is identified. The text in italics contains a commentary on the more significant differences.

National Electrical Code, NFPA 70	**IEC 60364**
Art. 90 Introduction	
90-1 Purpose *"The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity." Furthermore, Sec. 90-1(b) indicates that "this Code contains provisions that are considered necessary for safety. Compliance therewith and proper maintenance will result in an installation that is essentially free from hazard but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use." These statements correlate with Chapter 12 of IEC 60364.*	Chapter 12 Object Clause 131.1 (Ensure safety) *Clause 12.1 indicates that "this standard contains the rules for the design and direction of electrical installations so as to provide safety and proper functioning for the use intended." The rules are expressed in generalities, i.e. certain means of protection are required to be provided but the methods by which to accomplish the level of protection specified are not indicated. From Clause 12.1, it is also evident that the object of IEC 60364 is to provide safety and proper functioning for the use intended. If functioning is intended to include other than safety functions, such aspects are considered to be outside the scope of the NEC.*
90-2 Scope *The installations included or excluded from the scope of each of the two documents are similar.*	Chapter 11 Scope
90-3 Code Arrangement *See Assessment of Style and Attributes of this report.*	Part 1, Annex A Numbering system and plan of IEC 60364. Also see Annex A-2 of this report.
In addition, by use of the index and the specific requirements that, in most cases, are located in one particular part of the Code, the safety aspects of an installation can be readily assessed.	*There is no index to the IEC 60364 documents.*
90-4 Enforcement *Since the Code has the capability of being used as a legal document, issues relating to enforcement are important. These are covered in Sec. 90-4.*	Not covered *Aside from Chapter 6 on Verification, IEC 60364 does not address enforcement issues.*

National Electrical Code, NFPA 70	**IEC 60364**
90-5 Mandatory Rules and Explanatory Material *Mandatory rules, permissive rules, and explanatory material all are clearly defined. In addition, suitability for adoption as a legal document precludes recommendatory statements.*	Covered in ISO/IEC Directives, Part 3, Clause 6.5.1, 6.6.1, and Annex E. *Referenced text is reproduced in Annex C of this report.*
90-6 Formal Interpretation *The authority having jurisdiction for enforcement of the Code has the responsibility for making interpretations of the rules; however, there is a mechanism for obtaining formal interpretations by which clarification on the Code text, not particular installations, can be obtained.*	Not covered *Formal interpretation procedures are not in place.*
90-7 Examination of Equipment for Safety *In effect, these provisions relieve the inspection authority from delving into internal wiring of appliances and equipment, and rely for safe operation on equipment that has been certified by a qualified electrical testing laboratory as meeting appropriate identified standards.*	Part 6 Verification *Compliance with the safety requirements of the relevant equipment standards is to be made by visual inspection on permanently wired electrical equipment.*
90-8 Wiring Planning	Sec. 132 Design
90-9 Metric Units of Measurement	Not covered; inherently metric
Art. 100 Definitions Contains only those definitions essential to proper application of the *Code*. *This analysis includes the definitions for which a corollary can be made to an IEC 60050 definition and those needed for clearer understanding of the U.S. Safety System.*	Part 2 Definitions Chapter 21 Guide to general terms. Status: Purely informative in nature. Contains informative notes only for some terms in IEC 60050 (826). *Inside the covers of IEC publications is a note on terminology referring readers to IEC 60050, International Electrotechnical Vocabulary. The following definitions are from IEC 60050. The definitions are preceded by the IEC 60050 Part designation in parentheses. Brackets contain the title of the Part (for other than Part 826: Electrical Installations of Buildings).*
Ampacity: The current in amperes that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.	(826) Current-carrying capacity (of a conductor) (continuous): The maximum current which can be carried continuously by a conductor under specified conditions without its steady state temperature exceeding a specified value.
Approved: Acceptable to the authority having jurisdiction.	

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Branch Circuit: The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).	(826) Final circuit (of buildings): A circuit connected directly to current-using equipment or to socket outlets.
Disconnecting Means: A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.	(826) Isolation: A function intended to cut off for reasons of safety the supply from all or a discrete section of the installation by separating the installation or section from every source of electrical energy.
Enclosure: The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.	(826) Enclosure: A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact.
Equipment: A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as a part of, or in connection with, an electrical installation.	(826) Electrical equipment: Any item used for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy, such as machines, transformers, apparatus, measuring instruments, protective devices, equipment for wiring systems, appliances.
Exposed (as applied to live parts): Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See “Accessible” and “Concealed”)	(826) Direct contact: Contact of persons or livestock with live parts.
Feeder: All circuit conductors between the service equipment or the source of a separately derived system and the final branch-circuit overcurrent device.	(826) Distribution circuit (of buildings): A circuit supplying a distribution board.
Grounded, Effectively: Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages that may result in undue hazards to connected equipment or to persons.	
Grounding Conductor, Equipment:	(826) Protective conductor (symbol PE): A

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The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system.	conductor required by some measures for protection against electric shock for electrically connecting any of the following parts: - exposed conductive parts, - extraneous conductive parts, - main earthing terminal, - earth electrode, - earthed point of the source, or - artificial neutral.
Grounding Electrode Conductor: The conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment or at the source of a separately derived system.	(826) Earthing conductor: A protective conductor connecting the main earthing terminal or bar to the earth electrode.
Guarded: Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger.	(826) Barrier: A part providing protection against direct contact from any usual direction of access and (826) Obstacle: A part preventing unintentional direct contact, but not preventing direct contact by deliberate action.
Identified (as applied to equipment): Recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular *Code* requirement. FPN: Suitability of equipment for a specific purpose, environment, or application may be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification may include labeling or listing. (See definitions of Labeled and Listed.)	
Interrupting Rating: The highest current at rated voltage that a device is intended to interrupt under standard test conditions.	(441) Short circuit breaking capacity: A breaking capacity for which the prescribed conditions include a short circuit at the terminals of the switching device . [Switchgear, controlgear, and fuses]
Isolated (as applied to location): Not readily accessible to persons unless special means for access are used. Labeled: Equipment or materials to which has been attached a label, symbol, or other identifying mark of	

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an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.	
Listed: Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation or products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or services meets identified standards or has been tested and found suitable for a specified purpose. FPN: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. Use of the system employed by the listing organization allows the authority having jurisdiction to identify a listed product.	
Live Parts: Electric conductors, buses, terminals, or components that are uninsulated or exposed and a shock hazard exists.	(826) Live part: A conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor. Note: This term does not necessarily imply a risk of electric shock.
Overcurrent: Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault. FPN: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore the rules for overcurrent protection are specific for particular situations.	(826) Overcurrent: Any current exceeding the rated value. For conductors, the rated value is the current-carrying capacity.
Overload: Operation of equipment in excess of normal, full-load rating, or of a conductor in excess	(151) Overload: The excess of actual load over full load.

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of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.	Note: The term "overload" should not be used as a synonym for "overcurrent." [Electrical and Magnetic Devices]
Premises Wiring (System): That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of their associated hardware, fittings, and wiring devices, both permanently and temporarily installed, that extends from the service point of utility conductors or source of a separately derived system to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.	(826) Wiring system: An assembly made up of a cable or cables or busbars and the parts which secure and, if necessary, enclose the cable(s) or busbars.
Qualified Person: One familiar with the construction and operation of the equipment and the hazards involved.	(826, Amd 2) Skilled person: A person with relevant education and experience to enable him or her to avoid dangers and to prevent risks which electricity may create. Instructed person: A person adequately advised or supervised by skilled persons to enable him or her to avoid dangers and to prevent risks which electricity may create. Ordinary person: A person who is neither a skilled person nor an instructed person.
Service Drop: The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.	(601) Supply service: A branch line from the distribution system to supply a customer's installation. [Generation, transmission, and distribution of electricity—General]
Service Lateral: The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service-entrance conductors in a terminal box or meter or other enclosure with adequate space, inside or outside the building wall. Where there is no terminal box, meter, or other enclosure with adequate space, the point of connection shall be considered to be the point of entrance of the service conductors into the building.	(601) Supply service: Same as above.
Service Point: Service point is the point of	(604) Point of supply: A point in the electrical system

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connection between the facilities of the serving utility and the premises wiring.	where the technical and commercial criteria of supply are specified. [Generation, transmission, and distribution of electricity—Operation] (826) Origin of an electrical installation: The point at which electrical energy is delivered to an installation.
Utilization Equipment: Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes.	(826) Current-using equipment: Equipment intended to convert electrical energy into another form of energy, for example light, heat, motive power.
Voltage, Nominal: A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480Y/277 volts, 600 volts). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.	(826) Nominal voltage (of an installation): Voltage by which an installation or part of an installation is designated.
Art. 110 Requirements for Electrical Installations	
110-2 Approval *This is basically a restatement of the definition of "Approved" with explanatory references to two other statements in the Code. These statements are significant in enforcement of the Code rules.*	Not addressed *IEC 60364 does not address issues relating to acceptance of an installation.*
110-3 Examination, Identification, Installation, and Use of Equipment *This section is equivalent of Part 3 of IEC 60364, Assessment of General Characteristics and Chapter 61, Initial Verification.*	Part 3 Assessment of General Characteristics Chapter 6 Initial verification *Clause 312.2 on types of system earthing includes supply systems which, under the NEC rules, are prohibited due to inherent hazards that may result from ground faults in equipment or wiring systems. One such system is the TT system which relies on earth as the sole fault current return path. Sec. 250-2(d) specifically indicates that the earth shall not be used as the sole equipment grounding conductor or fault current path.* *Clause 320.2 contains an extensive list of codified environmental, physical, and other external influences, each with a specific designation. Under the NEC, such codification*

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	is not considered necessary because Code rules and equipment markings identify the suitability of electrical equipment for the use conditions for which it has been evaluated.
110-4 Voltages	512.1.1 Voltage
110-5 Conductors	Chapter 52 Wiring systems
110-6 Conductor Sizes (in AWG or circular mils)	Table 52J (Metric) Minimum cross-sectional area of conductors
110-7 Insulation Integrity *The specification that completed wiring installations shall be free from short circuits and grounds, other than as required or permitted in Art. 250, does not prescribe test methods or insulation resistance values.* *In a compliant installation, insulation integrity is achieved by use of wiring materials and equipment that has been certified to specified and identified standards and by proper installation verified by the acceptance authorities.*	612.3 Insulation resistance of the electrical installation *Test methods, test voltages, and minimum insulation resistance values are prescribed.*
110-8 Wiring Methods	Sec. 521 Types of wiring systems
110-9 Interrupting Rating *See commentary under 110-10.*	Sec. 434 Protection against short-circuit currents 533.2 Selection of devices for protection of wiring systems against overloads
110-10 Circuit Impedance and Other Characteristics *Compliance with Secs. 110-9, 110-10, and 250-2, as well as predominant use of the solidly grounded supply systems and known performance characteristics of overcurrent protective devices (see definition of "Overcurrent"), all ensure that fault currents are terminated in sufficient time not to damage permanently installed wiring at other than fault location, ignite adjacent combustible material, or introduce the risk of electric shock for persons in contact with exposed dead metal parts.* *Except as covered in Arts. 430 and 440 on motors and equipment incorporating hermetic motor compressors, typically the same device serves as an overcurrent protective device for protection against overloads, short circuits, or ground faults.*	131.4 Protection against overcurrent 131.5 Protection against fault currents Sec. 435 Coordination of overload and short-circuit protection *Permission for use of the TT electricity supply system necessitates use of various protective devices to avert risks of electric shock and to have a means to terminate ground fault conditions.*

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110-11 Deteriorating Agents	Chapter 32 Classification of external influences; Sec. 321: Environments
110-12 Mechanical Execution of Work	134.1.1 (Good workmanship and proper materials)
110-13 Mounting and Cooling of Equipment	134.1.5 (Cooling conditions not impaired) 422.2 (Mounted to allow safe dissipation of heat)
110-14 Electrical Connections *Establishes correlation between Code rules and use conditions for which equipment is evaluated.*	134.1.4 (Safe and reliable connections) 522.5.2 (Dissimilar metals) Sec. 526 Electrical connections
110-18 Arcing Parts	422.3 Where arcs and sparks are emitted…
110-19 Light and Power From Railway Conductors *Trolley wires with ground returns are permitted to supply some lighting and power circuits in car houses, power houses, etc., operated in connection with electric railways. In these limited applications, it is the only provision in the NEC that permits for lighting and some power circuits to use exposed grounded conductors and parts as the only return.*	312.1 Types of system earthing *No system permits load currents to be returned solely on exposed earthed conductors or conductive parts. However, if equipment on a TNC system becomes extraneously earthed, part of the neutral current would flow over the earthed parts. (This is a similar situation as the service connections under the NEC.)*
110-21 Marking	Sec. 514 Identification
110-22 Identification of Disconnecting Means *This section addresses not only identification of disconnecting means, but also indicates that if a series combination of overcurrent devices is used, use of the system, the system rating, and that identified replacement components are needed is also covered by the marking requirement. Because of the dynamic conditions during the interruption process of short-circuit currents, the acceptability of a series combination of the two overcurrent devices and the host equipment can be determined only by test. Equipment so evaluated is marked with information indicated above.*	Sec. 514 Identification *Covers identification of purpose of switchgear and controlgear; identification of wiring for specific reasons; color coding of neutral and protective conductors; identification of protective devices as to circuit, etc.; and provision of diagrams.* 434.3.1 Breaking capacity *Covers series combinations of short circuit protective devices. Note recommends obtaining of details on coordination from equipment manufacturer.*
110, Part C Over 600 V, Nominal, or Less *Many installations in buildings, such as high-rise buildings and campus type facilities, include installations of circuits operating at over 600 volts, nominal (typically not over 35 kV). Therefore, rules are necessary for circuits operating at over 600 volts, nominal.*	IEC 60364 Scope, Chapter 11 covers installations up to 1000 V, ac (1500 V, dc) only
110-26 Spaces About Electrical Equipment	134.12 Accessibility of electrical equipment

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	481.2.4 Minimum distances to be observed in operating and maintenance gangways Sec. 513 Accessibility
110-27 Guarding of Live Parts	131.2.1 Protection against direct contact 411.3.2 Protection against direct contact
Art. 200 200-1 Scope	
200-2 General *With some exceptions, all premises wiring systems are required to have a grounded conductor, which is required to be insulated beyond the service equipment.*	312.2 Types of system earthing 546.2.2 The PEN conductor shall be insulated to the highest voltage to which it may be subjected to avoid stray currents
200-3 Connection to Grounded System *In conjunction with the foregoing section, the electricity supply system also is required to have a grounded circuit conductor (N or PEN conductor). This rules out use of type IT supply systems, except in a few specialized cases, one of which is in patient care areas covered in Art. 517.*	312.2 Types of system earthing *See commentary under system grounding in Art. 250.*
200-6 Means of Identifying Grounded Conductors *Requires use of white or natural gray color for grounded circuit conductors.*	514.3 Identification of neutral and protective conductors *Per IEC 60446:* *Neutral: Light blue.* *Protective: Green with yellow stripe. Acknowledges U.S. color coding for grounded and equipment grounding conductors.*
200-7 Use of White or Natural Gray Color	Same as for Sec. 200-6
200-9 Means of Identification of Terminals	Not addressed
200-10 Identification of Terminals (for grounded circuit conductor)	Not addressed
200-11 Polarity of Connections	Not addressed
Art. 210 Branch Circuits 210-1 Scope *Covers branch circuits other than for motors, which are included in Art. 430. A branch circuit by definition is unidirectional. A final ring circuit would be considered a parallel circuit because current to any one outlet point flows from two different directions. Only size No. 1/0 and larger*	314.1 [Division into several (final) circuits] 433.3 Does not prohibit final ring circuits *Final ring circuits rule out use of receptacle type feed-through RCDs.*

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conductors are permitted to be paralleled.	
210-2 Other articles for Specific-Purpose Branch Circuits *References to other articles or sections for requirements concerning specific-purpose branch circuits assists user of the document.*	Part 7 Requirements for special installations or locations *Some sections in Part 7 include special rules for circuits and cables.*
210-3 Rating *The rating of the branch circuit is defined by the ampere rating or setting of the overcurrent device. For multioutlet branch circuits, their ratings are required to be 15, 20, 30, 40, or 50 amperes.*	No specified ratings for multioutlet circuits
210-4 Multiwire Branch Circuits *Addresses disconnecting means (isolation) for outlets supplied by multiwire branch circuits.*	312.1 Types of system of live conductors *Includes ac circuits of single-phase, 2- or 3-wire; 2-phase, 3- or 5-wire; 3-phase, 3- or 4-wire; and dc circuits, 2- or 3-wire*
210-5 Identification for Branch Circuits	See 200-6
210-6 Branch-Circuit Voltage Limitations *The limitation of 120 volts, nominal, between conductors in dwelling unit circuits that supply lighting fixtures and cord-and-plug connected loads of 1440 VA, is a significant limitation that exists in North America and some other countries around the world. Due to the lower voltage, protection against indirect contact can be more readily achieved. Typically, larger loads are supplied by the ungrounded (phase) conductors of 120/240 V, single-phase, 3-wire branch circuits, or 240 V circuits derived from the 120/240 V supply.* *In 120 V circuits where the circuit conductor and the equipment grounding conductor are of equal size, the maximum voltage that could appear on an equipment or appliance enclosure during a ground fault condition would be 60 V. In a comparable 240 V circuit the touch voltage would be 120 V under the same fault conditions. The potential of a higher touch voltage has influenced the IEC 60364 rules. Coupled with the higher voltage are the supply system earthing rules which would permit the higher touch voltages to exist for long periods of time, thus necessitating use of RCDs to limit the duration of the hazardous condition. In a 120 V system under the rules of the NEC, the lower touch voltage, supply system grounding rules, and requirements for*	Not specified *IEC 60364 rules are based on the European system of 230 volt branch circuits without regard to other countries that utilize different systems.*

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effective grounding paths ensure that in circuits of practical lengths, the hazardous voltages under fault conditions are terminated in a short period of time. Also see comments on Sec. 210-8.	
210-7(a) through 210-7(e) Receptacles and Cord Connectors (Grounding Requirements)	413.1.1.2 Earthing (other than the general provisions for earthing, no other specifications)
210-7(f) Noninterchangeable Types (Receptacles) *This provision is needed due to the presence of 120 and 240 volt circuits in dwelling units. In other occupancies, circuits of other voltages with socket outlets may be present. Other than in recreational vehicles and marine craft, extra-low voltage circuits supplying power are extremely rare. Art. 720 on circuits and equipment operating at less than 50 volts has been left over from earlier times when some rural premises were supplied only by wind power and storage batteries operating at the low voltage. Sec. 210-7(f) is applicable regardless of the types of voltages present.*	411.3.4 Plugs and socket outlets (for FELV systems only) *Considerable detail in requirements is provided in Sec. 411 covering protection against both direct and indirect contact by extra-low voltage, SELV, and PELV sources. This appears to be an indication that extra-low voltage sources for supplying limited amounts of power are prevalent. Plugs on SELV and PELV circuits are not prohibited from having the same configuration as 230 volt socket outlets.*
210-8 Ground-Fault Circuit-Interrupter Protection for Personnel *Provision of ground-fault circuit-interrupter protection for personnel requirements have resulted in a notable reduction in electrocutions in the U.S. These devices are required to have a trip setting of 4-6 mA of ground-fault current. This level of protection ensures that a person being subjected to the shock current has the ability to let go of the hazardous object. Typically, these devices are installed at locations or circuits for which they are specified. Thus, they are not subjected to excessive leakage currents which may cause nuisance tripping. Concepts of whole-house protection have been explored, however, increases in design trip point, which would be necessary, were considered to be a reduction in the level of safety. Further efforts in whole-house protection methods are not being actively pursued by use of GFCI type devices.*	412.5 Additional protection by residual current devices 531.2 Residual current devices *Clause 412.5 specifies that protection by residual current devices (RCDs) is to be provided as an additional protection method against electric shock. The primary protection methods include insulation of live parts, barriers or enclosures, obstacles, and placing out of reach.* *The rated operating current for the RCDs is not to exceed 30 mA. In the opinion of the U.S. National Code Committee, a 30 mA trip rating is too high to prevent serious physiological effects other than ventricular fibrillation. These other effects include inability to let go, interference with breathing, etc. (according to publication by Biegelmeier, Skuggevig, and Takahashi, "The Influence of Low-Voltage Network Systems on the Safety of Electrical Energy Distribution," © 1995, UL).* *For other than horticultural and agricultural buildings, the IEC 60364 documents specify 30 mA maximum RCDs only as a method of protection against electric shock. For the above two types of premises, 705.422 specifies 0.5 A RCDs as protection against fire.* *Even though IEC 60364 documents specify 30 mA RCDs only for protection against indirect contact, there are indications that to achieve the disconnecting times in Table 41A of Sec.*

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	413 in an economical manner, RCDs with ratings up to 300 mA are used in Europe and possibly elsewhere. Typically, these devices supply all or a number of circuits in premises.
210-9 Circuits Derived from Autotransformers	Not specifically covered
210-10 Ungrounded Conductors Tapped from Grounded Systems	Sec. 312 (permits tapping of ungrounded conductors from some earthed supply systems)
210-11 Branch Circuits Required *Based on load calculations as specified in Art. 220 and the proliferation of electrical appliances, specific requirements for providing separate branch (final) circuits was deemed necessary.*	132.3 Nature of demand *Indicates only the parameters that need to be considered in determining the number and types of circuits required.*
210-12 Arc-Fault Circuit-Interrupter Protection *Recent developments in technology have resulted in devices that are intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing, and by functioning to de-energize the circuit when an arc fault is detected. The protection circuitry can be built into a circuit breaker, a separate device for installation at the distribution panelboard, an outlet type device, or be built into utilization equipment. This requirement is new for the 1999 NEC and it applies only to branch circuits containing receptacle outlets installed in dwelling unit bedrooms. The requirement becomes effective January 1, 2002.*	Not specified
210-19 Conductors— Minimum Ampacity and Size *Due to the performance characteristics of overcurrent devices used in conjunction with the NEC, the minimum conductor size is to be based on the noncontinuous load plus 125% of the continuous load connected to the branch circuit. Continuous load is defined as a load that operates continuously for three hours or more. Typically, such loads are lighting loads, air conditioning loads, and electric heating loads.* FPN No. 4 provides information on voltage drop, which for other than fire pump motors, is considered a design consideration, not safety. The provisions in this section also specify the minimum size of branch circuit conductors which is No. 14 AWG (2.08 mm²). Some exceptions permit	Sec. 133 Selection of electrical equipment 133.2 Characteristics Sec. 524 Cross-sectional areas of conductors and Table 52J *Table 52J indicates minimum size conductors for various applications. For power and lighting circuits, the table indicates 1.5 mm² copper which is close to size No. 16 AWG, and 2.5 mm² for aluminum conductors. Aluminum conductors in the smaller sizes (No. 12 and No. 10 AWG) are no longer available in the U.S.* *Sec. 525 has a title voltage drop in consumers' installations. This section is indicated as under consideration. There is no indication on voltage drop for other than consumers' installations. Some generic statements are made in Chapter 45 on protection against undervoltage, leaving the protection needed*

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tap conductors as small as size No.18 AWG (0.823 mm²).	*as a judgment item.*
210-20 Overcurrent Protection *Although the main overcurrent protection rules are in Art. 240, Sec. 210-20 deals specifically with branch circuit conductors and equipment.*	131.4 Protection against overcurrent 131.5 Protection against fault currents *Sec. 131 addresses separately protection against overcurrent and protection against fault currents. By contrast, in the NEC, overcurrent includes overload, ground-fault, and short-circuit currents. Except in specialized cases, the same overcurrent device protects wiring and equipment against all of the foregoing potential hazards.*
210-21 Outlet Devices	Not detailed
210-23 Permissible Loads	Not detailed
210-24 Branch-Circuit Requirements—Summary	Not detailed
210-25 Common Area Branch Circuits	Not detailed
Art. 210, Part C Required Outlets *The objective of specifying locations for outlets, including receptacle outlets (socket outlets), is to minimize the use of extension cords and long flexible power supply cords for utilization equipment. Fires and electric shock have been identified as originating from damaged or abused flexible cords. The requirements for receptacles at work spaces, such as countertops in kitchens, are intended to prevent running cords across heated surfaces or basins with water.*	Not specified
Art. 215 Feeders *Feeders typically extend from service equipment of the premises to one or more distribution panelboards. These panelboards in turn supply branch circuits. The rules address minimum rating and size, ampacity relative to service-entrance conductors, overcurrent protection, use of common neutral conductors, need for diagrams, and various other aspects in regard to auto transformers and tapping circuits from a feeder. A ground-fault circuit interrupter protection can be used on a feeder to protect all of the branch circuits emanating from the supplied distribution panelboard. Also, each feeder having a disconnect rated 1000 amperes or more and connected in specified voltage circuits, is required to be provided with ground-fault protection of equipment. The equipment ground-fault protectors operate at a level below the potential short-circuit current of a circuit and they operate before extensive*	Distribution circuits—General rules apply 314.2 Separate distribution circuits where separate control is needed *Judgment needs to be exercised in providing separate distribution circuits and those parts of the circuits where separate control is needed.*

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equipment damage has taken place.

Art. 220 Branch-Circuit, Feeder and Service Calculations

The NEC contains specific rules for calculating the size of electrical service, feeders, and branch circuits, and how much load can be safety connected to each. General lighting loads are based on volt-amperes per square foot and the volt-ampere values vary between 0.25 and 3.5 VA per square foot. There are various demand factors for multiple loads where all of the loads are not expected to be energized at the same time. For feeder and service loads, there are optional calculations which are permitted to be used. Farms have a different load composition, therefore, separate rules are specified for computing farm loads.

133.2.4 Power equipment is to be selected to be suitable for the load

Sec. 311 Maximum demand and diversity

Maximum demand and diversity are two factors that need to be considered in sizing electrical circuits, and the power equipment is to be selected to be suitable for the load. No guidance is provided for determining diversity factors and conditions under which they can be applied. Each country has to determine the minimum safe electrical service that can be provided for premises and how much load can be applied to each circuit.

Art. 225 Outside Branch Circuits and Feeders

This article covers all aspects involved in outside branch circuits. It references articles where special rules regarding outside branch circuits are involved. The general rules cover support and spacing of open conductors, clearances from buildings, connection between more than one building or other structure, grouping of disconnects, and special rules for over 600 volt installations.

General rules apply, based on assessment of general characteristics

General rules throughout the IEC 60364 documents apply.

Art. 230 Services

This article on supply services provides rules for coordination of practices and the needs of the supplying utility and those of premises wiring. It includes the main control and protection requirements for the complete premises, whether it be a building or other structure.

It is to be noted that the NEC permits up to six disconnects as the main disconnecting means for the premises. All six are to be grouped in one location or in one piece of equipment, so that disconnection can be accomplished readily in case of an emergency.

Service conductors are considered to be protected only from overload on the load end. Protection of supply transformers and the service conductors up to the service point are governed by rules of the supplying utility, not by the NEC. The model code for the electric utilities is the National Electrical Safety Code, issued by the Institute of Electrical and Electronic Engineers (IEEE).

Because of the consequences of insulation failure or ground fault, only specific wiring methods as detailed in Sec. 230-43

No special rules for supply services

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are permitted for services. For services of 1000 amperes or more under certain voltage conditions, ground-fault protection of equipment is required. The maximum setting of the ground fault protection is required to be 1200 amperes and the maximum time delay is to be one second for ground-fault currents equal to or greater than 3000 amperes. The ground fault protection equipment is to be performance tested when first installed at the site and a record is to be kept to be available for the authority having jurisdiction.	
Art. 240 Overcurrent Protection 240-1 Scope—For Equipment and Conductors	
240-2 Protection of Equipment *Art. 240 contains the general rules for overcurrent protection against overload, short-circuits, and ground faults. Due to the differing operating characteristics and use conditions, protection at various current levels, and selection of the types of devices are necessary for different applications as indicated in the table in this section.*	131.4 Protection against overcurrent 131.5 Protection against fault currents *The need for different levels of overcurrent protection necessary for various types of equipment and operating conditions as may exist are not specified. IEC rules stop at the outlets.*
240-3 Protection of Conductors *Protection of circuit conductors in accordance with their ampacity, sizes of equipment grounding conductors or other ground-return paths, and the operating characteristics of overcurrent devices ensure that ratings of overcurrent devices can be selected to appropriately protect the conductors from damage due to overheating without calculations of formulas and use of empirical factors.* *Typical IEC and North American fuse characteristics and North American circuit-breaker characteristics are shown in Annex F of this report.*	Chapter 43 Protection against overcurrent Sec. 473 Measures of protection against overcurrent Sec. 533 Devices for protection against overcurrent *The operating characteristics of overcurrent devices play a very important role in the ability to protect conductors. There are differences in fusing time/current characteristics between the types of fuses used in conjunction with the NEC rules and those of fuses used elsewhere.* *Some of the fuses used under the NEC have an intentional time delay at currents above 600% of the fuse rating. At lower current values, these fuses operate faster than the IEC fuses. For instance, a Type NOS100 (U.S.) fuse will operate in about 50 seconds at 200% current, whereas a BS88 100A fuse will operate in 300 seconds. At 1000% of current, the NOS100 fuse will operate in 0.6 seconds and the BS88 in 0.2 seconds. The longer time at the high current value is due to the built-in time delay to prevent nuisance operation with high inrush current loads. Another U.S. fuse, KTS-R 100A, operates at 200% current in 10 seconds. Also, at higher current values this fuse operates faster. It takes the BS88 fuse 1000% of current to operate in 0.2 seconds, but the KTS-R fuse will operate in 0.2 seconds at 500% of current. The KTS-R fuse could be used where fuses complying with IEC*

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	standards are required, but not the reverse.
240-4 Protection of Flexible Cords and Fixture Wires	Same as 240-3
240-6 Standard Ampere Ratings for Fuses and Fixed-Trip Circuit Breakers	Standard ratings of fuse links (fuses) are specified in IEC 269-1 Standard ratings of circuit breakers are implied by a reference to IEC 269-1 Note: 432.1 and 433.2 include type gI and gII fuses, which are not included in IEC 269-1, IEC 269-2 or IEC 269-3 *The references to the gI and gII fuses are being deleted by Amendment No. 1 to 60364-4-43, 1997-08.*
240-6(b), 240-6(c) Adjustable-Trip Circuit Breakers and Restricted Access	433.2 Coordination between conductors and protective devices (for overload current) Note: For adjustable devices, the setting selected is the rating of the device 533.1.4 Not possible to modify setting by ordinary person without use of a tool
240-8 Fuses or Circuit-Breakers in Parallel	Not addressed
240-9 Thermal Devices	432.2 Devices ensuring protection against overload only
240-10 Supplementary Overcurrent Protection	Not classed as such
240-11 Definition of Current—Limiting Overcurrent Device	Not included
240-12 Electrical System Coordination *Electrical system coordination is necessary only in specialized applications to minimize the hazards to personnel and equipment by properly localizing a fault condition to restrict outages to the equipment affected, which can be accomplished by the choice of selective fault-protective devices. Where such coordination is necessary, the time-current characteristics of the devices are reviewed and compared to ensure the desired performance is achieved.*	539.1 Discrimination between overcurrent protective devices *The requirements for discrimination between overcurrent protective devices have not been developed and are indicated as under consideration.*
240-13 Ground-Fault Protection of Equipment *Ground-fault protection of equipment provides fault current protection at current levels less than the prospective short-*	Equipment ground fault protection not specifically addressed

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circuit current. This limits the disturbance at the fault location and prevents damage to wiring insulation.	
240-20 Ungrounded Conductors (location of OC devices)	Sec. 431 Live conductors shall be protected 473.3.1 Protection of phase conductors
240-21 Location in Circuit *The rules for connection of overcurrent devices in an electrical circuit, as applicable to ungrounded (phase) conductors and neutral or grounded conductors, are similar between the two documents.*	473.1.1 Position of devices for overload protection 473.2.1 Position of devices for short-circuit protection
240-22 Grounded Conductor	473.3.2 Protection of the neutral conductor
240-23 Change in Size of Grounded Conductor	Not specifically addressed; general principles apply
240-24 Location In or On Premises	482.1.2 Switchgear and controlgear not in passageways, etc. (places of assembly)
240-30 Enclosures	412.2 Protection by barriers or enclosures
240-32 Damp or Wet Locations	Chapter 48 External influences
240-33 Vertical Position	Not addressed
Art. 240, Part D Disconnecting and Guarding	Chapter 46 Isolation and switching Sec. 537 Devices for isolation and switching
Art. 240, Parts E & F Fuses	Chapter 43 Protection against overcurrent Sec. 473 Measures of protection against overcurrent Sec. 533 Devices for protection against overcurrent
Art. 240, Part G Circuit Breakers	Same as for fuses
Art. 240, Part H Supervised Industrial Installations	Same as for fuses
Art. 240, Part I Overcurrent Protection, Over 600 V, Nominal	Scope limitation of 1000 V, nominal, ac
Art. 250 Grounding	312.2 Types of system earthing 413.1.1.2 Earthing (in Sec. 413 on protection against indirect contact)

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	413.1.2 Equipotential bonding 413.1.2.2 Supplementary equipotential bonding 413.1.3.1 & 413.1.3.2 TN systems (earthing) 442.2, etc. Earthing arrangements in transformer substations Chapter 54 (1980) Earthing arrangements and protective conductors
250-1 Scope *This article covers general requirements for grounding and bonding of electrical installations, and specific requirements in (a) through (f):* *(a) Systems, circuits, and equipment required, permitted, or not permitted to be grounded* *(b) Circuit conductor to be grounded on grounded systems* *(c) Location of grounding connections* *(d) Types and sizes of grounding and bonding conductors and electrodes* *(e) Methods of grounding and bonding* *(f) Conditions under which guards, isolation, or insulation may be substituted for grounding.*	
250-2 General Requirements for Grounding and Bonding *Indicates what grounding and bonding is intended to accomplish, and states that the prescriptive methods of Art. 250 shall be followed to comply with the performance requirements of this section.* *The performance requirements cover:* *(a) Grounding of electrical systems in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher voltage lines, and that will stabilize the voltage to earth during normal operation.* *(b) Grounding of electrical equipment to limit the voltage to ground on the equipment and to provide an effective path for fault currents.* *(c) Bonding of electrically conductive materials and other equipment, essentially to maintain equal potentials on conductive parts with respect to ground.* *(d) Performance of fault current path so as to safely carry maximum fault that may be imposed on it, and to have sufficiently low impedance to permit operation of overcurrent devices under fault conditions. The earth shall not be used as the sole equipment grounding conductor or fault current path.* *Note: Also see Annex D of this report for example circuits.*	541.1 The performance of earthing arrangements shall satisfy the safety and functional requirements of the electrical installation 542.1 Earthing arrangements 542.1.2 Requires earthing arrangements to provide: • a value of resistance in accordance with the protective and functional requirements of the installation • continuously effective earthing resistance • means to carry earth-fault and earth-leakage currents without danger • adequately robust installation

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250-4 Application of Other Articles *Lists references to other parts of the Code where requirements in addition to or different from Art. 250 requirements are contained.*	See commentary on Sec. 548 further below
250-6 Objectionable Current Over Grounding Conductors *Objectionable current can be considered as any current in the protective grounding system that may adversely affect the effectiveness of the protective function.* *Currents that affect functionality of equipment, i.e. currents that introduce data errors or electrical noise, are not considered objectionable by the Code rules.* *Currents that are intentionally introduced in a grounding system, such as those for cathodic protection, can be objectionable.* *AC coupling/dc isolating devices are permitted to limit the dc currents to parts of the system to be protected against corrosion. Also, Sec. 250-96(b) permits "isolated grounding" for reduction of electrical noise by a separate insulated equipment grounding conductor which is grounded only at the main grounding point. Thus, each piece of electronic equipment of an installation has a single point grounding connection eliminating circulating currents that may introduce data errors, etc.*	Sec. 545 Earthing arrangements for functional purposes 541.1 Earthing arrangements for functional purposes shall be provided to ensure correct operation of equipment or to permit reliable and proper functioning of equipment (further requirements under consideration) *From the foregoing and the content of Sec. 548 (see below), it is evident that electrical noise from equipment earthing arrangements is considered objectionable.* Sec. 548 Earthing arrangements and equipotential bonding for information technology equipment installations *This section covers use of main earthing terminal, compatibility of ITE installations with PEN conductors, electrolytic corrosion protection, provisions for EMC compatibility, and earthing and equipotential bonding for ITE installations.* *Some salient characterizations are:* *(a) The incompatibility of ITE installations on supply circuits where the neutral is also the protective earthing conductor (PEN conductor) is obvious because of different voltage levels on accessible equipment parts due to voltage drop in the neutral. (In the NEC, PEN conductors are not permitted within buildings). Clause 548.4 on the compatibility is only recommendatory.* *(b) Incompatibility and conflicting requirements are evident from 411.1.4.1 which prohibits earthing of SELV circuits; 548.3.1 Note, which indicates that as defined in IEC 950, SELV circuits are earthed. However, IEC 950 permits (does not require) earthing of SELV circuits (ostensibly for functional reasons, where necessary). Product standards do not appear to abide by installation rules.* *(c) It is only in Annex B (Informative) to Sec. 548 that the concepts of single point grounding [as specified in Sec. 250-96(b)] and equipotential bonding are presented. The most basic and most effective methods for achieving functionality of ITE are relegated to an informative annex.*

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250-20 AC Circuits and Systems to Be Grounded *Effectively, requires most systems at utilization voltages to be grounded.*	312.2 Types of system earthing *Defines various system earthing arrangements. Includes TT system where the earth is used as the fault current return path, IT system where the supply circuit is not earthed but the equipment is, and the TNC system where equipment is earthed by means of an earthed neutral.* *It is noted that nowhere in Chapter 54 is there a requirement that the earthing arrangements be one of those defined in Sec. 312. Only in Sec. 544 is there a note (informative) to Chapter 41 for TN, TT, and IT system earthing. Chapter 41 has 49 pages on protection against electric shock.*
250-21 AC Systems of 50-1000 V Not Required to Be Grounded *Defines conditions under which solid system grounding is not required.*	
250-22 Circuits Not to Be Grounded *Specifically prohibits grounding of the circuit (system) in three types of installations, where grounding would be more hazardous or the other safety systems required for those installations would be defeated.*	
250-24 Grounding Service-Supplied A-C Systems *Essentially requires grounding of the supply circuit by an accessible connection of the grounding electrode conductor to the load end of the service lateral or drop at the service disconnecting means. Applies to circuits that are required to be grounded. Where the installation includes an outdoor transformer, one additional connection to a grounding electrode is required outside the building. Prohibits grounding connections to circuits on the load side of service disconnecting means.*	312.2 Types of system earthing *See commentary opposite Sec. 250-20.*
Art. 280 Surge Arresters	Sec. 443 Protection against overvoltages of atmospheric origin or due to switching 534.2 Erection of surge protective devices in building installation 534.3 Selection of surge protective devices
Art. 300 Wiring Methods 300-1 Scope	11.2 It covers (Scope)

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300-1(b) Integral Parts of Equipment	11.2 b), c), and e) Excludes internal wiring of apparatus and appliances
300-2 Limitations (Voltage and Temperature)	Sec. 313 Supplies (assessment of characteristics—voltage) Sec. 523 Current-carrying capacities
300-3 Conductors	
300-3(a) Single Conductors	Sec. 521 Types of wiring systems
300-3(b) Conductors of the Same Circuit	521.5 AC circuits (all conductors of each circuit in same enclosure)
300-3(b)(1) Parallel Installation	473.2.4 Short circuit protection for conductors in parallel 523.6 Conductors in parallel
300-3(b)(2) Grounding Conductors	544.1 Note
300-3(b)(3) Nonferrous Wiring Methods	Single conductors entering ferromagnetic enclosures through separate entries not addressed
300-3(b)(4) Enclosures (neutral separate from switch leg)	Not addressed
300-3(c) Conductors of Different Systems	411.1.3 Arrangement of circuits (SELV & PELV) 413.5.1.5 (For protection by electrical separation—as for Art. 517 isolated power sources) 515.2 Segregated to prevent mutual detrimental influence
300-4 Protection Against Physical Damage	522.6 Impact 522.7 Vibration 522.8 Other mechanical stresses
300-5 Underground Installations	Table 52H, Reference numbers: 5, 5A, 21 through 24A, 52, 53, 61, 62, 63
300-6 Protection Against Corrosion	522.5 Presence of corrosive or pollution substances
300-7 Raceways Exposed to Different Temperatures	Other than fundamental principles, not covered
300-8 Installation of Conductors With Other Systems	528.2 Proximity to nonelectrical services

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300-10 Electrical Continuity of Metal Raceways and Enclosures	Sec. 526 Electrical connections
300-11 Securing and Supporting	Tables 52F, 52G, and 52H
300-13 through 300-16 Installation of Raceways and Conductor Connections	522.8.1.3 (Supported not to suffer damage) 522.8.1.5 (Access to draw in or out conductors) 526.3 (Connections accessible for inspection, etc.)
300-18(a) Raceway Installation—Complete Runs	522.8.1.1 (When buried in structure conduit and ducts to be complete)
300-19 Supporting Conductors in Vertical Raceways	522.8.1.4 (Not to suffer damage)
300-20 Induced Currents (grouping of conductors and single conductor entries into ferromagnetic enclosures)	521.5 All conductors to be grouped in same enclosure where ferromagnetic enclosures are used
300-21 Spread of Fire or Products of Combustion	527 Selection and erection to minimize the spread of fire (spread of products of combustion not addressed)
300-22 Wiring in Ducts, Plenums, and Other Air Handling Spaces	Not addressed
Art. 300, Part B Requirements for Over 600 V, Nominal	Scope limitation of 1000 V, nominal, ac
Art. 305 Temporary Wiring	Sec. 704 Construction and demolition site installations
305-1 Scope	704.1 Scope
305-2 All Wiring Installations	704.1.1 (Special requirements)
305-3 Time Constraints	Not stated
305-4 General	General rules apply
305-4(a) Services	704.511.1 Assemblies for distribution of electricity to comply with future IEC 439-4
305-4(b) Feeders	704.52 Wiring systems

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305-4(c) Branch Circuits	704.537 Devices for isolation and switching Same as for feeders
305-4(d) Receptacles	704.538 Plugs and socket outlets
305-4(e) Disconnecting Means	704.537 Devices for isolation and switching
305-4(f) Lamp Protection 305-4(g) Splices (box not required)	Not specifically stated Not specifically addressed
305-4(h) Protection from Accidental Damage	704.521.1.7.3 (Mechanical protection, not run across roads)
305-4(i) Termination(s) at Devices	704.521.1.7.3 (Nso strain or wiring terminations)
305-4(j) Support	Support methods not specified
305-6 Ground-Fault Protection for Personnel 305-7 Guarding (Over 600 V, Nominal)	704.471 Measures of protection against electric shock Scope limitation of 1000 V, nominal, ac
Art. 310 Conductors for General Wiring	Chapter 52 Wiring systems
310-1 Scope	Sec. 520 General Sec. 523 Current-carrying capacities
310-2 Conductors	
310-2(a) Insulated	133.2.1 Voltage
310-2(b) Conductor Material	Normative references
310-3 Stranded Conductors	Normative reference
310-4 Conductors in Parallel	433.3 Protection of conductors in parallel 523.6 Conductors in parallel
310-5 Minimum Size of Conductors	Sec. 524 Cross-sectional area of conductors Table 52J Minimum cross-sectional area of conductors
310-6 Shielding (Cables Above	Scope limitation of 1000 V, nominal, ac

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2000 V)	
310-8 Locations	522.3 Presence of water 522.11 Solar radiation
310-9 Corrosive Conditions	522.5 Presence of corrosive or pollution substances
310-10 Temperature Limitation of Conductors	523.1.1 Reference to Table 52-A
310-11 Marking	Normative references
310-12 Conductor Identification	See 200-6
310-13 Conductor Constructions and Applications	Normative references
310-14 Aluminum Conductor Material	Normative references
310-15 Ampacities for Conductors Rated 0–2000 V *A direct comparison of the ampacities under the rules of both codes can be made only by using detailed calculations which is outside the scope of this report. Some approximations can be made by interpolating between conductor sizes (cross-sectional areas) and given ampacities. This is best done by examples. Using Table 310-16 and assuming three 75°C rated conductors in conduit on a wall, 2.5 mm² standard IEC conductor size, and interpolating between Nos. 14 and 12 AWG conductors, the approximate ampacity for the 2.5 mm² conductor would be 21.7 A.*	Sec. 523 Current-carrying capacities *For the same example as on the left, according to Tables 52-B1, Column 5, and 52-C3, Column B, the 2.5 mm² PVC insulated conductors have an ampacity of 21 A. Taking into consideration that PVC insulated conductors in Sec. 523 are rated 70°C and the NEC ampacities for 75°C conductors are used, the ampacities under the rules of both codes appear to be relatively equivalent.*
As a second example, interpolating in the same manner as above, using single conductors in free air at 30°C, Table 310-17, size Nos. 4 and 3 AWG 75°C rated conductors, a 25 mm² conductor would have an ampacity of 139 A. Additional comparison of ampacities appears in Annex E of this report.	*For the second example, a PVC insulated 25 mm² conductor in free air and spaced from other conductors has an ampacity of 146 A, per Table 52-C9, Column G. Although this value is less conservative than the NEC, the difference is only about 5%. Many table values result in deviations from the technically correct values by as much as 7.5%. However, the graph in Annex E of this report shows that the NEC ampacities are consistently more conservative than those of Chapter 5 in IEC 60364.*

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Tables 310-16 and 310-17: Ambient Correction Factors (for conductors in raceways, cables, and free air)

Ambient Temp. (°C)	75°C Conductor Correction Factors
--	--
--	--
--	--
21-25	1.05
26-30	1.00
31-35	0.94
36-40	0.88
41-45	0.82
46-50	0.75
51-55	0.67
56-60	0.58
61-70	0.33

Table 52-D1: Correction factors for ambient air temperatures other than 30°C

Ambient Temp. (°C)	Correction Factors for PVC Insulated 70°C Conductors
10	1.22
15	1.17
20	1.12
25	1.06
--	--
35	0.94
40	0.87
45	0.79
50	0.71
55	0.61
60	0.50
--	--

Appendix B, Tables B310-7, B310-10: Correction Factors, 75°C Conductors, for Other Than 20°C Earth Temperature

Ambient Earth Temp. (°C)	Correction Factor
6-10	1.09
11-15	1.04
16-20	1.00
21-25	0.95
26-30	0.90
--	--

Table 52-D2: Correction factors for ambient ground temperatures other than 20°C

Ground Temp. (°C)	Correction Factors for PVC Insulated 70°C Conductors
10	1.10
15	1.05
--	--
25	0.95
30	0.89
35	0.84

[Table continues to 60°C]

The slight differences in the correction factors of the two codes can probably be attributed to the 75°C vs. 70°C insulation temperature rating and, in some cases, rounding up or rounding down.

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Table 310-15(b)(2)(a): Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable
[Applies also to single conductors or multiconductor cables in free air, stacked or bundled more than 24 in. (0.61 m)]

Number of Current-Carrying Conductors	Percent of Values in Tables 310-16 or 316-17
--	--
4-6	80
7-9	70
10-20	50
10-20	50
10-20	50
21-30	45
21-30	45
31-40	40
41 and above	35

The foregoing adjustment factors apply where all current-carrying conductors carry current continuously. Where load diversity is involved, such as may be the case in numerous industrial applications, for more than nine conductors in a raceway or cable, Table B310-11 provides factors with less severe reduction in ampacities than the values shown above.

Conductor sizes and types have an influence on the amount of current a conductor can carry where the conductor is installed in close proximity to other current-carrying conductors. For practical reasons the numbers given for the adjustment factors are not exact. However, they serve well to ensure minimum levels of safety that can be achieved by design, installation, and verification.

Table 52-E1: Correction factors for groups of more than one circuit or more than one multicore cable
[Note 6 has been applied to the number of single core cables to facilitate direct comparison]

Number of Circuits in Table 52-E1	Number of Loaded Single-Core Conductors in a Group	Correction Factors for Values in Tables 52-C1 to 52-C6
1	3	1.00
2	6	0.80
3	9	0.70
4	12	0.65
5	15	0.60
6	18	0.55
7	21	0.55
8, 9, 10	24-30	0.50
12, 14	36-42	0.45
16, 19, 20	48-60	0.40

The foregoing values apply to single-core conductors or cables bunched on a surface or enclosed in conduit or trunking.

Table 52-E1 is expressed in terms of numbers of circuits and multicore cables. According to Note 6, for groups of single-core conductors the number of groups of conductors have to be divided either by two or three to arrive at the number of circuits in the Table. This alternative can result in a difference of five percentage points in some correction factors.

310-60 Conductors Rated 2001–35,000 V

Scope limitation of 1000 V, nominal, ac

Art. 318 Cable Trays
This article covers four types of cable trays: ladder type, ventilated trough, ventilated channel, and solid bottom type. There are different rules for each construction due to their means for dissipation of heat, provision of physical protection, support for conductors, and other aspects as covered in the

Chapter 52 Wiring systems; cable ladder; and cable tray
Cable ladders and cable trays are included among all other wiring systems covered in Part 5. Solid bottom, perforated trays, and ladders are indicated in Table 52H. Other than the fundamental principles on safety and the correction factors

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article. *Cable trays are a support method for cables and raceways, but they are not to be treated as a raceway system. The rules in Art. 318 are distinct and different from those for raceway systems covered in other articles of Chapter 3. The open construction, provision of direct ventilation, ability to maintain routing, and separation between cables or raceways—all of these allow rules that achieve effective levels of safety, different from those for enclosed raceways.* *The rules include the types of cables and raceways that may be placed in a cable tray, construction specifications, installation as a complete system, accessibility, grounding, installation of cables, allowable cable fill, and ampacity of cables. These rules vary for single or multiconductor cables and for the type of cable tray construction.* *The comprehensive and specific rules provide for uniform application and enforcement to provide equivalent levels of safety from one installation to the next.*	*for current-carrying capacity in Tables 52-E4 and -E5, there are no other rules to guide the installer or verifier. Notes which are not part of the requirements allude to potential problems with certain installations, such as with more than one layer of conductors and how to treat parallel conductors.*
<u>Arts. 320 through 365</u> *These articles cover wiring methods which are the only ones permitted by Sec. 110-8. The methods include open wiring on insulators, concealed knob-and-tube wiring, messenger supported wiring, various types of cables, conduit, tubing, raceways, and wireways. These methods do not include cable trays which are considered a support method, not a raceway.* *One or more of the following features or installation provisions are specified; the general rules in Art. 300 apply:* *(a) Uses permitted, not permitted—Indicates whether installation is permitted in open and accessible or concealed spaces, indoors or indoors and outdoors, in ordinary or corrosive atmospheres, where exposed to physical damage, for direct burial in earth, and the like.* *(b) Permitted raceway and cable sizes—Usually specifies minimum and maximum sizes. Relates to requirements for maximum distances between supports and radii of bends.* *(c) Permitted conductor sizes—Typically applies to cables, surface raceways, and wireways. Relates to loading, etc. for which the product has been certified.* *(d) Permitted single conductor (single core) cables—Only some cables are permitted to be of the single-conductor type. Potential misuse is the reason. For multiconductor cables, the number of conductors typically is not limited.* *(e) Spacing between supports—For rigid tubular raceways, maximum distance between supports can vary with size. For other raceways and cables set distances from termination at an*	Sec. 521 Types of wiring systems *Tables 52F, 52G, and 52H cover types of wiring methods somewhat similar to those of the NEC. There does appear to be more extensive use of multiconductor cables by themselves and in conduit, cable trunking, cable tray, and cable ducting. Some of the methods shown in Table 52H are not permitted by the NEC. For instance, insulated conductors installed in mouldings, reference No. 71, are not permitted. Also, methods Nos. 73 and 74 would be accepted only where the window frames and architraves containing the insulated conductors of power circuits are parts of assemblies certified for the specific use.* *In accordance with 521.1, the installer has to ascertain that the relevant product standards cover the external influences to which the wiring method will be exposed. It is not clear how this is to be accomplished.* *Details as to maximum wire fill, types of cables that may be run exposed or in cable tray, maximum number of bends, minimum bending radii, maximum distance between supports, suitability of the conduit, trunking system, or cable armor for use as a protective earthing conductor are not specified.* *The rationale for the requirement in 522.8.1.7 is not clear. This clause requires that wiring systems which are rigidly fixed and buried in the walls shall be run horizontally or vertically or parallel to the room edge.* *It appears that rules in Sec. 523 on current-carrying capacity address cables with a maximum of five cores, which would*

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enclosure and between intermediate supports are specified. Varies with type of cable or flexible raceway. *(f) Maximum number of bends—Usually not more than 360 degrees between access points. Applies to raceways into which conductors are pulled and which do not have openable covers.* *(g) Minimum bending radius—Can vary according to size. Typically for cables the minimum bending radius is expressed as a multiple of the cable diameter.* *(h) Maximum raceway fill—For tubular raceways, the maximum fill is expressed as a percentage of cross-sectional area. It is 53% for one conductor in a raceway, 31% for two conductors, and 40% for three or more conductors in tubular raceways. For other raceways and wireways different requirements exist, depending on type.* *(i) Fittings—Appropriate fittings certified for use are required. Expansion fittings are required for rigid nonmetallic raceways of other than short lengths.* *(j) Suitability as an equipment grounding conductor—Each article indicates whether a metallic raceway is suitable for use as an equipment grounding conductor. In some cases, this feature is conditional upon certification of particular constructions for such use.* *(k) Marking—In addition to manufacturers' identification required by Sec. 110-21, other markings, depending on raceway type, are required by the Code. Product standards may specify additional markings.* *Because typically an installer is working with one wiring method at a time, having the rules for each system in a separate article facilitates clear understanding of the applicable requirements.*	*contain three phase conductors, a neutral conductor, and a PE conductor. Apparently, multiconductor cables with a larger number of conductors are not covered by these rules. This may be an impediment to practical installations of multiple circuits being contained in a cable as, for instance, from a panelboard to a final circuit distribution point, sometimes called a "home run." Also, the rules for current-carrying capacity of cables address only cables without armor (523.1.4 of 64/1039/FDIS). It is not stated how the current-carrying capacity is to be determined for armored cables.*
Art. 370 Outlet Boxes, Etc.	412.2 Protection by barriers or enclosures 481.2 Measures of protection against direct contact Location of boxes, maximum wire fill, closure of openings, methods of support, treatment of conductor entries, and construction specifications not addressed
Art. 373 Cabinets, Cutout Boxes, and Meter Socket Enclosures	Other than 522.8.1 and 522.8.1.2, bending radius such that no damage to insulation and sheath—location, closure of openings, methods of support, and construction specifications are not addressed
Art. 374 Auxiliary Gutters	Same as for Art. 370

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Art. 380 Switches	Sec. 537 Devices for isolation and switching
Art. 384 Switchboards and Panelboards	Chapter 53 Switchgear and controlgear
Art. 400 Flexible Cords and Cables *Typically, flexible cords are used in factory- or field-made cord sets, or power supply cords, as pendants, and as replacement for damaged cords. The larger cables and those for specific uses are covered as well to assure uniformity in construction and performance. Even though there are product standards that contain detailed requirements, the Code rules address general characteristics such as identification, range of sizes, type, and thickness of insulation, outer covering, and use for which the cord or cable is intended.*	Normative references, Chapter 52 on wiring systems 522.7 Vibration *Wiring systems shall be suitable for such conditions. Also, 522.8.1.8 indicates that flexible wiring systems shall be installed so that excessive tensile stress to the conductors and connections is avoided.* *Since the IEC 60364 rules cover wiring from the service to the socket outlets, power supply cords for current-using equipment or other cords, such as for pendants, are not addressed.*
Art. 402 Fixture Wires	Normative references, general rules
Art. 410 Lighting Fixtures, Lampholders, Lamps, and Receptacles	Normative references, general rules
Art. 422 Appliances	Normative references, general rules
Art. 424 Fixed Electric Space-Heating Equipment	Normative references, general rules
Art. 426 Fixed Outdoor Electric Deicing and Snow-Melting Equipment	Normative references, general rules
Art. 427 Fixed Electric Heating Equipment for Pipelines and Vessels	Normative references, general rules
Art. 430 Motors, Motor Circuits, and Controllers	Normative references, general rules
Art. 440 Air Conditioning and Refrigerating Equipment Note: Also see Annex D of this report for an example circuit	Normative references, general rules
Art. 445 Generators	Sec. 551 Low-voltage generating sets
Art. 450 Transformers and Transformer Vaults (Including Secondary Ties)	Types of transformers under the scope of Art. 450 not covered

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Art. 455 Phase Converters	Single-to-three-phase phase converters not specifically covered
Art. 460 Capacitors	Capacitors under the scope of Art. 460 not covered
Art. 470 Resistors and Reactors (Rheostats are covered in Sec. 430-82)	Devices of this type not specifically covered
Art. 480 Storage Batteries	Not specifically covered
Art. 490 Equipment, Over 600 V, Nominal	Scope limitation, 1000 V, nominal, ac
Arts. 500 through 505, 510, 511, 513 through 516 Hazardous (Classified) Locations [Explosive Atmospheres] Art. 505 is harmonized with IEC 60079	Not covered by IEC 60364; IEC requirements for explosive atmospheres are covered by IEC 60079
Art. 517 Health Care Facilities Secs. 517-19(e), (f); 517-30(c)(2); 517-33(a)(2); 517-160	413.5 Protection by electrical separation
Art. 518 Places of Assembly Including Arts. 520, 525, 530, and 540	Sec. 711 Exhibitions, shows, and stands
Art. 545 Manufactured Buildings	Not addressed
Art. 547 Agricultural Buildings	Sec. 705 Electrical installations of agricultural and horticultural buildings
Art. 550 Mobile Homes	Not addressed
Art. 551 Recreational Vehicles and Recreational Vehicle Parks	Sec. 708 Electrical installations of caravan parks and caravans
Art. 552 Park Trailers	Not addressed
Art. 553 Floating Buildings	Not addressed
Art. 555 Marinas and Boatyards	Sec. 709 Marinas and pleasure craft

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Art. 600 Electric Signs and Outline Lighting	Not addressed
Art. 604 Manufactured Wiring Systems	Not addressed
Art. 605 Office Furnishings (Consisting of Lighting Accessories and Wired Partitions)	Sec. 713 Furniture
Art. 610 Cranes and Hoists	Not addressed
Art. 620 Elevators, Escalators, Etc.	Not addressed
Art. 625 Electric Vehicle Charging System Equipment	Not addressed
Art. 630 Electric Welders	Not addressed
Art. 640 Audio Signal Processing, Amplification, and Reproduction Equipment	Not addressed
Art. 645 Information Technology Equipment	Sec. 707 Earthing requirements for the installation of data processing equipment
Art. 650 Pipe Organs	Not addressed
Art. 660 X-Ray Equipment	Not addressed
Art. 665 Induction and Dielectric Heating Equipment	Not addressed
Art. 668 Electrolytic Cells	Sec. 706 Restrictive conducting locations
Art. 669 Electroplating	Not specifically addressed
Art. 670 Industrial Machinery	Not covered (covered by IEC 60204-1)
Art. 675 Electrically Driven or Controlled Irrigation Machines	Not addressed
Art. 680 Swimming Pools, Fountains, and Similar Installations	Sec. 702 Swimming pools and other basins

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Art. 680, Part G Hydromassage Bathtubs	Sec. 701 Locations containing bathtub or shower basin
Art. 685 Integrated Electrical Systems	Not specifically addressed
Art. 690 Solar Photovoltaic Systems	Not specifically addressed
Art. 695 Fire Pumps	Not addressed
Art. 700 Emergency Systems	Chapter 56 Safety services
Art. 701 Legally Required Standby Systems	Chapter 56 Safety services
Art. 702 Optional Standby Systems	Not addressed
Art. 705 Interconnected Electric Power Production Sources	Not addressed
Art. 720 Circuits and Equipment Operating at Less Than 50 V	Not addressed
Art. 725 Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits	SELV, PELV, and FELV circuits
Art. 760 Fire Alarm Systems	Not specifically addressed
Art. 760, Part C Power-Limited Fire Alarm (PLFA) Circuits	SELV, PELV, and FELV circuits
Art. 770 Optical Fiber Cables and Raceways	Not addressed
Art. 780 Closed-Loop and Programmed Power Distribution	Not addressed
Art. 800 Communications Circuits	Not specifically covered (some provisions of Secs. 443 and 528 apply)
Art. 810 Radio and Television Equipment	Not specifically covered (some provisions of Secs. 443 and 528 apply)

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<u>Art. 820 Community Antenna Television and Radio Distribution Systems</u>	Not specifically covered (some provisions of Secs. 443 and 528 apply)
<u>Art. 830 Network-Powered Broadband Communications Systems</u>	Not specifically covered (some provisions of Secs. 443 and 528 apply)

<u>Chapter 9 Tables:</u>

Table 1 Percent of Cross Section of Conduit and Tubing for Conductors	Not addressed
Table 4 Dimensions and Percent Area of Conduit and Tubing	Not addressed
Table 5 Dimensions of Insulated Conductors and Fixture Wires	Normative references
Table 5A Compact Aluminum Building Wire Nominal Dimensions* and Areas (*dimensions are from industry sources)	Normative references
Table 8 Conductor Properties	Normative references

CROSS-REFERENCES, IEC 60364 TO *NEC*

IEC 60364	*National Electrical Code, NFPA 70*
<u>Part 1 (1992-10)</u>	
Chapter 11 Scope, object, and fundamental principles	90-2 Scope
Chapter 12 Object	90-1(a) Purpose
Chapter 13 Fundamental principles	90-1(b) Adequacy
131 Protection for safety:	See the following:
131.1 General	90-1(a)
131.2 Protection against electric shock	110-17(a) Live parts guarded against accidental contact 110-34 Workspace and guarding Art. 430, Part L Protection of Live Parts (motor installations) 725-2 Class 2 circuit
131.3 Protection against thermal effects	110-18 Arcing parts 410-5 Fixtures near combustible material 384-7 Location relative to easily ignitable material
Risk of persons suffering burns	Product standards
131.4 Protection against overcurrent	Art. 240 Overcurrent Protection
131.5 Protection against fault currents	250-2 Effective grounding path Art. 240 Overcurrent Protection Art. 430, Parts D & E Motor Feeder; Branch-Circuit, Short-Circuit, and Ground-Fault Protection
131.6 Protection against overvoltage	250-2(a), 300-3(c), Art. 725
131.6.1 Fault between circuits	300-3 (c) Conductors of different systems 725-54 Installation of conductors and equipment (Class 2 circuits)

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131.6.2 Due to atmospheric phenomena or switching	Art. 280 Surge Arresters Art. 800, Part C Protection (Communications Circuits) Product standards
132 Design	90-1(c) Intention
133 Selection of electrical equipment	110-2 through 110-11
134 Erection and initial verification of electrical installations:	See the following:
134.1 Erection	110-12 Mechanical execution of work Art. 200, 310-11, 310-12 384-3(e) 110-14 110-13 384-7
134.2 Initial verification	110-3 110-7
<u>Part 2 Definitions (1993-01)</u> Normative reference to IEC 60050 (826)	Art. 100 Definitions
<u>Part 3 Assessment of general characteristics (1993-03)</u> Normative references: IEC 60617-11 Graphical symbols for diagrams IEC 60721 Classification of environmental conditions Parts 3-0, 3-3, 3-4 Amd 2: Adds 11 normative references	Art. 110 Requirements for Electrical Installations Art. 220 Branch-Circuit, Feeder, and Service Calculations Art. 250, Part B Circuit and Systems Grounding Arts. 500 through 505 Explosive Atmospheres (hazardous locations) Art. 230 Services 300-6 Protection against corrosion 300-7 Raceways exposed to different temperatures
<u>Part 4 Protection for safety</u>	Throughout the *NEC* and product safety standards
Chapter 41 (1992-10) Protection against electric shock	Throughout the *NEC* and product safety standards
60364-4-41, Amd 1 Adds: 41.1 Scope Adds: 41.2 Normative references Adds: Various notes	

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411 Protection against both direct and indirect contact:	See the following:
411.1 Protection by extra-low voltages SELV and PELV	Arts. 725 and 760, Tables 11(a), 11(b), 12(a), and 12(b). Class 2, Class 3 circuits, and power limited fire alarm circuits
411.2 Protection by limitation of discharge energy (under consideration)	Addressed by product standards
411.3 FELV system	Addressed by product standards
411.3.4 Plugs and socket outlets	210-7(f) Noninterchangeable receptacles and attachment plugs
412 Protection against electric shock in normal service:	See the following:
412.1 …by insulation of live parts	410-3, 422-4 Insulation
412.2 …by barriers or enclosures	110-27, 110-31 Guarding of live parts
412.3 …by obstacles	Not specified as a method of protection
412.4 …by placing out of reach	110-17(a)(3) and (4) Location and elevation 410-3, Exc. Elevation
412.5 Additional protection by RCDs	210-7(d), 422-8(d)(3), 210-8, 215-9, 426-31, Exc., 427-26, Exc., 305-6, 511-10, 680-70, 680-26(b), 680-51(a), 555-3, 517-20(a), 550-8(b), 550-23(d), 680-5, 680-6, 680-21, 680-31, 680-62(a), 551-41(c), 551-71 Ground-fault circuit-interrupters
413 Protection against indirect contact:	See the following:
413.1 …by automatic disconnection of supply	Same as for 412.5 above
413.1.1.2 Earthing	Art. 250 Grounding
413.1.2 Equipotential bonding	Art. 250, 547-9 Equipotential bonding

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413.2 Protection by use of Class II equipment or by equivalent insulation	250-114, Exc. 422-16(b), Excs. Double insulated equipment
413.3 …by nonconducting location	Not specifically addressed
413.4 …by earth-free local equipotential bonding	Not specifically addressed
413.5 …by electrical separation	517-19(e), (f) 517-30(c)(2) 517-33(a)(2) 517-160 Isolated power systems
Chapter 42 (1980) Protection against thermal effects	See the following:
422 Protection against fire	In general, covered by product standards
422.2 Surface temperatures	410-5 Fixtures near combustible material 410-65 Temperature (recessed fixtures) 410-73(e) Thermal protection (electric discharge fixtures) 422-17 Protection of combustible material 424-13 Spacing from combustible material
422.3 Arcs or sparks	110-18 Arcing parts 384-7 Location relative to easily ignitable material
422.4 Focusing of radiated heat energy	Product requirements and markings
422.5 Electrical equipment containing flammable liquid	Arts. 500 through 516
423 Protection against burns	Product standards
424 Protection against overheating	Product standards and: 422-46 Flatirons
424.1 Forced air heating systems	424-64 Limit controls
424.2 Appliances producing hot water or steam	422-47 Water heaters 424-73 Overtemperature limit control (boilers) 424-83 Overtemperature limit control (electrode type boilers)

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Chapter 43 (1977) Protection against overcurrent	Art. 240 Overcurrent Protection 440-C Air conditioning and refrigerating equipment 422-11 Appliances 210-20 Branch circuits 364-9 through 364-13 Busways 460-8(b) Capacitors 240-G Circuit breakers 240-4, 400-13 Cords, flexible, and tinsel 240-11 Current limiting, definition 240-D Disconnecting and guarding 424-22 Electric space heating equipment 240-C Enclosures 240-21, 430-28 Feeder taps 240-4, 402-12 Fixture wires 240-E, 240-F Fuses and fuseholders 445-4 Generators 240-22 Grounded conductor 240-A Installation 410-103 Lighting track 230-91, 240-B Location 430-C, 430-D Motors, motor circuits, controllers 430-72 Control circuits 430-125 Over 600 volts 240-8, 380-17 Multiple fuses and circuit breakers (in parallel) 240-24(b) Occupant access 225-9 Outside branch circuits and feeders 240-H, 460-25 Over 600 volts 384-15, 384-16 Panelboards 240-8, 380-17 Paralleled fuses and circuit breakers 240-3(l) Remote-control circuits 230-G Service entrance conductor 210-20 Single appliance 240-10 Supplementary 384-2 Switchboards 450-3 through 450-5 Transformers 240-33 Vertical position, enclosures
431 General	Art. 240 Overcurrent Protection of Conductors
432 Nature of protective devices	Art. 240, Parts E & F Fuses Art. 240, Part G Circuit Breakers 430-40 Overload relays 430-52(c)(3) Instantaneous trip circuit breaker

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433 Protection against overload current	240-3 Protection of conductors 240-4 Protection of flexible cords and fixture wires Art. 430, Part C Motor and Branch-Circuit Overload Protection
433.3 Conductors in parallel	310-4 Conductors in parallel
434 Protection against short circuit currents: 434.1 Protective devices to break short-circuit current	See the following: 110-9 Interrupting rating 110-10 Circuit impedance and other characteristics 240-83(c) Interrupting rating (series rating)
434.2 Determination of prospective short-circuit currents	110-10 Circuit impedance and other characteristics
434.3 Characteristics of short-circuit protective devices	110-9 Interrupting rating 240-83(c) Interrupting rating 240-86 Series Ratings 110-22 (Series combination field marking)
434.3.2 Interrupting time	Product standards
435 Coordination of overload and short-circuit protection	430-52(c)(3) Combination motor controller
436 Limitation of overcurrent by characteristics of supply	Art. 725 Class 2 Circuits Class 3 Circuits Art. 760 Power Limited Fire Alarm Circuits 690-8(b)(3), Exc. Conductors sized for short-circuit current of photovoltaic source
60364-4-43, Amd 1 (1997-08) Revised values for calculations for allowable short-circuit currents that may last up to five seconds	Performance requirements in product standards
Chapter 44 Protection against overvoltages	See the following:
442 (1993-02) Protection of low-voltage installations against faults between high-voltage systems and earth	Not covered in the *NEC*. Covered by National Electrical Safety Code, ANSI C2 with reference to IEEE Guide for Safety in AC Substation Grounding
443 (1995-04) Protection against overvoltages of	Art. 280 Surge Arresters

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atmospheric origin or due to switching	Art. 800, Part C Protection (Communications Circuits) Product standards
444 (1996-04) Protection against EMI in installations of buildings	Effects of EMI reduced by use of TN-S or TN-CS power systems and by circuit segregation requirements
Chapter 45 (1985) Protection against undervoltage 451 General	700-12(a), 700-12(e) Emergency systems (safety services), sources of power
Chapter 46 (1981) Isolation and switching 461 General 462 Isolation 463 Switching off for mechanical maintenance 464 Emergency switching, including emergency stopping 465 Functional switching (control)	440-B Air conditioning and refrigerating equipment 422-C Appliances 460-8(c) Capacitors 424-C Electric space heating equipment 240-40 Fuses and thermal cutouts 110-22 Identification 430-127, 430-H Motors and controllers 250-24(c) Separate building on same premises 230-F Services 230-82 Connections, ahead of 230-205, 230-206 Over 600 volts
Chapter 47 Application of protective measures for safety	
471 (1981) Measures of protection against electric shock	See Chapter 41
471, Amd 1 (Adds sub-clause 471.2.3 on RCDs for outdoor socket outlets)	210-8(a)(3)
473 (1977) Measures of protection against overcurrent	See Chapter 43
Chapter 48 Choice of protective measures as a function of external influences	See Chapter 41
481 (1993-07) Selection of measures for protection against electric shock in relation to external influences	See Chapter 41
482 (1982) Protection against fire:	See the following:

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482.1 Conditions of evacuation in an emergency	
482.1.1 (On wiring systems)	518-4 Wiring methods (places of assembly) 520-5 Wiring methods (theaters and audience areas of studios)
481.1.2 (Switchgear, controlgear)	384-5 Location of switchboards
Part 5 Selection and erection of electrical equipment	
Chapter 51 (1997-06) Common rules	
510 Common rules:	See the following:
510.1 Scope	
510.2 Normative references	No normative references
511 Compliance with standards	110-2, 110-3
512 Operational conditions and external influences:	See the following:
512.1 Operational conditions	
512.1.1 Voltage	110-4, 220-2
512.1.2 Current	110-3, 110-9
512.1.3 Frequency	110-3
512.1.4 Power	110-3
512.1.5 Compatibility	110-3
512.2 External influences and Table 51A	110-3, 110-11
513 Accessibility	110-26, 110-34, 300-23 Panels to allow access 370-29 Boxes to be accessible
514 Identification:	See the following:

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514.1 General	110-21, 110-22
514.2 Wiring systems	310-11
514.3 Identification of neutral and protective conductors	Art. 200, 250-57, 310-12
514.4 Protective devices	110-22, 384-13
514.5 Diagrams	215-5 Diagrams of feeders
515 Prevention of mutual detrimental influence:	See the following:
515.1 Unenclosed equipment on building surfaces	110-31 Enclosures for electrical installations
515.2 Inductive effects and "cross-talk"	Design consideration
515.3 EMC	Design consideration
Chapter 52 (1993-10) Wiring systems 520 General 520.1 (ref. to fundamental principles)	Art. 110, Chapter 3
520.2 Normative references	No normative references
521 Types of wiring systems 521.1 Method of installation (types of conductors) 521.2 Method of installation (Table 52G) 521.3 Examples, Table 52H	Art. 318 Cable Trays Art. 320 Open Wiring on Insulators Art. 321 Messenger Supported Wiring Art. 324 Concealed Knob-and-Tube Wiring Art. 325 Integrated Gas Spacer Cable Art. 326 Medium Voltage Cable, Type MV Art. 328 Flat Conductor Cable, Type FCC Art. 330 Mineral-Insulated, Metal-Sheathed Cable, Type MI Art. 331 Electrical Nonmetallic Tubing Art. 333 Armored Cable, Type AC Art. 334 Metal-Clad Cable, Type MC Art. 336 Nonmetallic-Sheathed Cable, Types NM, NMC, NMS Art. 338 Service-Entrance Cable, Types SE, USE

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	Art. 339 Underground Feeder and Branch-Circuit Cable Art. 340 Power and Control Tray Cable, Type TC Art. 342 Nonmetallic Extensions Art. 343 Nonmetallic Underground Conduit with Conductors Art. 345 Intermediate Metal Conduit Art. 346 Rigid Metal Conduit Art. 347 Rigid Nonmetallic Conduit Art. 348 Electrical Metallic Tubing Art. 349 Flexible Metallic Tubing Art. 350 Flexible Metal Conduit Art. 351 Liquidtight Flexible Metal and Nonmetallic Conduit Art. 352 Surface Metal and Nonmetallic Raceways Art. 354 Underfloor Raceways Art. 356 Cellular Metal Floor Raceways Art. 358 Cellular Concrete Floor Raceways Art. 362 Metal and Nonmetallic Wireways Art. 363 Flat Cable Assemblies
521.4 Busbar trunking systems	Art. 364 Busways
521.5 AC circuits	300-3(b) Conductors of the same circuit 300-5(i) Conductors of the same circuit (underground installations) 300-20 Induced currents in metal enclosures or metal raceways
521.6 Conduits and trunking systems	300-3(c) Conductors of different systems
522 Selection and erection in relation to external influences:	See the following:
522.1 Ambient temperature	310-10 Temperature limitation of conductors
522.2 External heat sources	310-10
522.3 Presence of water	430-11 Protection against liquids (motors)
522.4 Presence of solid foreign bodies	370-17(a) Openings to be closed
522.5 Presence of corrosive or pollution substances	300-6 Protection against corrosion
522.6 Impact	See applicable wiring system uses permitted/not

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	permitted
522.7 Vibration	430-13 Bushings (motors) 445-8 Bushings (generators)
522.8 Other mechanical stresses	See applicable wiring system 300-19 Supporting conductors in vertical raceways
522.9 Presence of flora and/or mould growth	225-26 Vegetation
522.10 Presence of fauna	Art. 547 Agricultural Buildings
522.11 Solar radiation	310-10 Temperature limitation of conductors
522.12 Seismic effects	Covered by local ordinances
522.13 Wind	Same as for 522.8
522.14 Building design	300-5(j) Ground movement
523 (1983) Current carrying capacities	310-15 Ampacities
523.1 General (Table 52A)	Table 310-13
523.2 Ambient temperature	Tables 310-16, 310-17, 310-18, 310-19 Ambient correction factors
523.3 Soil thermal resistivity	310-15 and Appendix B
523.4 Groups containing more than one circuit	Table 310-16, Note 8 Adjustment factors for more than three conductors in a raceway or cable
523.6 Conductors in parallel	310-4 Conductors in parallel
523.7 Variation of installation conditions along a route	310-15(c) Selection of ampacity
Tables 52-C1 through 52-C6 incl.	Tables 310-16, 310-17, 310-18, 310-19
Chapter 53 (1994-06) Switchgear and controlgear	
531 Devices for protection against indirect	See the following:

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contact by automatic disconnection of supply:	
531.1 Overcurrent protective devices	250-2 Effective grounding path Art. 240 Overcurrent Protection
531.2 Residual current protective devices	Same as for Clause 412.5
531.3 Insulation monitoring devices	517-160(b) Line isolation monitor
532 Devices for protection against thermal effects (under consideration)	422-46 Flatirons (temperature limiting means) 422-47 Water heaters (limit control) 424-73 Boilers (overtemperature limit control) 424-83 Electrode type boilers (overtemperature limit control) Product standards
533 Devices for protection against overcurrent:	See the following:
533.1 General requirements	
533.1.1 Screw-in fuses	Art. 240, Part E Plug Fuses, Fuseholders, and Adapters 240-250(d) No energized parts
533.1.2 Plug-in fuse carriers	Covered by fuseholder and host equipment requirements
533.1.3 Replacement of fuse-links	240-40 Disconnecting means for fuses 240-41 Arcing or suddenly moving parts
533.1.4 Circuit breakers	Art. 240, Part G Circuit Breakers
533.2 Selection of devices for protection of wiring systems against overloads	240-3 Protection of conductors 240-4 Protection of flexible cords and fixture wires Art. 430, Part C Motor and Branch-Circuit Overload Protection
Cyclic loads	430-33 Intermittent and similar duty (motors) Also see special installations, Part 7
533.3 Selection of devices for protection of wiring systems against short circuits	See 131.5
534 (1997-11) Devices for protection against overvoltages	See 443
535 Devices for protection against undervoltage	See Chapter 45

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537 (1981) Devices for isolation and switching	See Chapter 46
60364-5-537, Amd 1 (1981) Adds impulse voltage test values for isolation devices	Product requirements
539 Coordination of various protective devices	A design consideration
Chapter 54 (1980) Earthing arrangements and protective conductors	Art. 250 Grounding
542 Connections to earth:	See the following:
542.1 Earthing arrangements	250-2 General requirements for grounding and bonding
542.2 Earth electrodes	Art. 250, Part C Grounding Electrode System
542.3 Earthing conductors	Art. 250, Part F Equipment Grounding Conductors
542.4 Main earthing terminals or bars	250-130 Equipment grounding conductor connections 250-24 Grounding service-supplied AC systems 250-28 Main bonding jumper
542.5 Interconnection with earthing arrangements of other systems	800-40(d) Bonding of electrodes
542.5.1 Higher voltage systems (under consideration)	Art. 250, Part K Grounding of Circuits of 1 kV and Over
542.5.2 Lightning protection systems (under consideration)	Art. 280, Part C Connecting Surge Arresters
543 Protective conductors:	See the following:
543.1 Minimum cross-sectional areas	Table 250-122
543.2 Types of protective conductors	250 Types of equipment grounding conductors
543.3 Preservation of electrical continuity of protective conductors	250-124 Equipment grounding conductor continuity
544 Earthing arrangements for protective purposes:	See the following:
544.1 Protective conductors used with	250-134(b) With circuit conductors

IEC 60364	*National Electrical Code, NFPA 70*
overcurrent protective devices	
544.2 Earthing and protective conductors for fault-voltage operated protective devices	Fault-voltage operated protective devices not specifically addressed
544.3 Excessive earth-leakage currents (under consideration)	250-6 Objectionable current over grounding conductors
545 Earthing arrangements for functional purposes	Not covered; not related to safety
546 Earthing arrangements for combined protective and functional purposes:	See the following:
546.1 General (requirements for protective purposes prevail)	Functional currents not permitted over grounding conductors, per 250-6
546.2 PEN conductors	A conductor serving as a neutral and for equipment grounding permitted only for services
60364-5-54, Amd 1 Revises 546.2.1. Changes aluminum conductor size from 10 mm² to 16 mm² for PEN conductors	Size of grounded service neutral dependent on rating of service
547 Equipotential bonding conductors	547-9 Grounding, bonding, and equipotential plane (agricultural buildings)
548 (1996-02) Earthing arrangements and equipotential bonding for information technology installations	645-15 Grounding (information technology equipment)
Chapter 55 Other equipment:	See the following:
551 (1994-10) Low voltage generating sets	Art. 445 Generators Art. 705 Interconnected Electrical Power Production Sources 250-6 Portable and vehicle-mounted generators 250-30 Grounding separately derived AC systems
Chapter 56 (1980) Safety services	Art. 700 Emergency Systems Art. 701 Legally Required Standby Systems Art. 695 Fire Pumps Art. 517, Part C Essential Electrical Systems (Health Care

IEC 60364	*National Electrical Code, NFPA 70*
	Facilities; includes emergency systems)
Part 6 Verification	
Chapter 61 (1986) Initial verification	90-7 Examination of equipment for safety 110-3 Examination, identification, installation, and use of equipment 110-7 Insulation integrity
Part 7 Requirements for special installations or locations	
701 (1984) Locations containing a bathtub or shower basin	210-8 Ground-fault circuit-interrupter protection for personnel: 210-8(a) Dwelling units (1) Bathrooms 210-8(b) Other than dwelling units (1) Bathrooms 210-52(d) Bathrooms (dwelling unit receptacle outlets) 240-24(e) Not located in bathroom (overcurrent devices) Art. 680, Part G Hydromassage Bathtubs 380-4 Wet locations (switches) 410-4(d) Above bathtubs (fixtures) 410-57(c) Bathtub and shower space (receptacles)
702 (1997) Swimming pools and other basins	Art. 680 Swimming Pools, Fountains, and Similar Installations
703 (1984) Locations containing sauna heaters	Product safety standards and rules for damp or wet locations at elevated temperatures apply
704 (1989-03) Construction and demolition site installations	Art. 305 Temporary Wiring
705 (1984) Electrical installations of agricultural and horticultural premises	Art. 547 Agricultural Buildings
706 (1983) Restrictive conducting locations	Not specifically addressed
707 (1984) Earthing requirements for installation of data processing equipment (function related)	645-15 Grounding

IEC 60364	***National Electrical Code, NFPA 70***
708 (1988) Electrical installations in caravan parks and caravans	Art. 551 Recreational Vehicles and Recreational Vehicle Parks Art. 552 Park Trailers
60364-7-708, Amd 1 (1993-07) Amends Sub-clause 5.7.1 (12, 24, or 48 V)	Art. 551, Part B Low-Voltage Systems Low voltage defined as 24 V or less
709 (1994-09) Marinas and pleasure craft	Art. 555 Marinas and Boatyards Water craft covered by U.S. Coast Guard
711 (1998-03) Exhibitions, shows, and stands	Art. 520 Theaters and Similar Locations Art. 525 Carnivals and Similar Events Art. 530 Motion Picture and TV Studios and Similar Locations
713 (1996-02) Furniture	Art. 605 Office Furnishings
714 (1996-04) External lighting installations:	See the following:
714.11 Scope	90-2 Scope
Remainder of Sec. 714	Art. 402 Fixture Wires Art. 410 Lighting Fixtures, etc. Art. 411 Lighting Systems Operating at 30 V or Less

ANNEX A-1

LAYOUT AND ARRANGEMENT OF THE *NEC*

Chapter 1—General Chapter 2—Wiring and Protection Chapter 3—Wiring Methods and Materials Chapter 4—Equipment for General Use	Apply generally to all electrical installations
Chapter 5—Special Occupancies Chapter 6—Special Equipment Chapter 7—Special Conditions	Can supplement or modify Chapters 1 through 4
Chapter 8—Communications Systems	Chapter 8 is independent and Chapters 1 through 7 only apply where referenced within Chapter 8
Chapter 9—Tables	Applicable as referenced
Appendix A through D	The appendixes are for information only and are not mandatory

ANNEX A-2

NUMBERING SYSTEM AND PLAN OF IEC 60364

Table A.1—Numbering System of IEC 60364

Arabic numerals only are used (except for Tables and Figures; see below). The various divisions and subdivisions of the publication are identified as follows:		Examples
Parts	Sequentially by a single number:	4
Chapters	Sequentially within each part by the part number, followed by a single number, with no points:	41
Sections	Sequentially within each chapter by the part and chapter numbers, followed by a single number, with no points:	413
Clauses	Sequentially within each by the part, chapter, and section numbers, followed by a point and then the clause number: NOTES 1—The number of clauses may, if necessary, exceed nine: 2—Where a chapter has no sections, the absence of sections is indicated by the use of a zero in the position normally occupied by the section number: 3—Where introductory or general clauses appear before the division of a part of a chapter into sections, zeros are used in the positions normally occupied by the chapter and/or section numbers:	413.5 413.12 330.1 400.1
Sub-clauses	Sequentially within each clause by a further point and sub-clause number:	542.1.1
Tables and Figures	By the part and chapter number in which they appear, followed alphabetically by a capital letter:	Table 41 A

Table A.2—Plan of IEC 60364: Electrical Installations of Buildings

Part Nos. and Chapters	*Title*
Part 1 [1]	Scope, object, and fundamental principles
Chapter 11 Chapter 12 Chapter 13	Scope Object Fundamental principles
Part 2 [1]	Definitions
Chapter 21	Guide to general terms
Part 3 [1]	Assessment of general characteristics
Chapter 31 Chapter 32 Chapter 33 Chapter 34 Chapter 35	Purposes, supplies, and structure Classification of external influences Compatibility Maintainability Safety services
Part 4 [11]	Protection for safety
Chapter 41 Chapter 42 Chapter 43 Chapter 44 Chapter 45 Chapter 46 Chapter 47 Chapter 48	Protection against electric shock (protection against direct and indirect contact) Protection against thermal effects (of equipment during normal operation) Protection against overcurrent (for conductors and cables) Protection against overvoltage Protection against undervoltage Isolation and switching Application of protective measures for safety Choice of protective measures as a function of external influences
Part 5 [10]	Selection and erection of electrical equipment
Chapter 51 Chapter 52 Chapter 53 Chapter 54 Chapter 55 Chapter 56	Common rules (e.g., principles for selection and erection) Wiring systems Switchgear and controlgear Earthing arrangements and protective conductors (also equipotential bonding conductors) Other equipment Safety services (selection and erection of the equipment for safety services)
Part 6 [1]	Verification
Chapter 61	Initial verification (prior to commissioning of the installation)
Part 7 [13]	Requirements for special installations or locations
NOTE	Part 7 deviates from Parts 1 to 6 in that it is not divided into chapters but into sections, in order to have more than nine sections available for these additional regulations
Section 702	Swimming pools
Section 703	Location containing sauna heaters
Section 704	Construction and demolition site installation
Section 705	Electrical installations of agricultural and horticultural premises
Section 706	Restrictive conducting locations
Section 708	Electrical installations in caravan parks and caravans

Table A.2—Plan of IEC 60364: Electrical Installations of Buildings

Part Nos. and Chapters	*Title*
Section 709	Electrical installations in marinas and pleasure craft
Section 710	Medical locations and associated areas
Section 711	Electrical installations in exhibitions, shows, stands, and fun fairs
Section 712	Not allocated
Section 713	Furniture
Section 714	External lighting installations

Note: The numbers in brackets indicate the number of separate documents in each part.

ANNEX B-1

NORMATIVE REFERENCES IN IEC 60364

Note: Only one location for the referenced documents is indicated.
Cross-references to IEC 60364 requirements are not included.

Location and Number of Standard	*Title*
60364-1-132.5	
IEC 721	Classification of environmental conditions
60364-1-134.1.3	
IEC 446	1989, Identification of conductors by colors or numerals
60364-2-21.0	
IEC 50 (826)	1982, International electrotechnical vocabulary; Chapter 826: Electrical installations of buildings
60364-3-3.2	
IEC 617-11	1983, Graphical symbols for diagrams; Part 11—Architectural and topographical installation plans and diagrams
60364-3-3.2	
IEC 721-3-0	1984, Classification of environmental conditions—Part 3: Classification of groups of environmental parameters and their severities. Introduction
60364-3-3.2	
IEC 721-3-3	1987, Classification of environmental conditions—Part 3: Classification of groups of environmental parameters and their severities. Stationary use at weatherprotected locations
60364-3-3.2	
IEC 721-3-4	1987, Classification of environmental conditions—Part 3: Classification of groups of environmental parameters and their severities. Stationary use at non-weatherprotected locations
60364-3-3.2, Amd 2	
IEC 255-22-1	1988, Electrical relays—Part 22: Electrical disturbance tests for measuring relays and protection equipment—Part 1: 1 MHz burst disturbance tests

Location and Number of Standard	*Title*
60364-3-3.2, Amd 2	
IEC 801-4	1988, EMC for industrial process measurement and control equipment—Part 4: Electrical fast transient / burst requirements
60364-3-3.2, Amd 2	
IEC 1000-2-1	1990, Electromagnetic compatibility (EMC)—Part 2: Environment—Section 1: Description of the environment—Electromagnetic environment for low-frequency conducted disturbances and signaling in public power supply systems
60364-3-3.2, Amd 2	
IEC 1000-2-2	1990, Electromagnetic compatibility (EMC)—Part 2: Environment—Section 2: Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems
60364-3-3.2, Amd 2	
IEC 1000-2-5	1995, Electromagnetic compatibility (EMC)—Part 2: Environment—Section 5: Classification of electromagnetic environments
60364-3-3.2, Amd 2	
IEC 1000-4-2	1995, Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 2: Electrostatic discharge test—Basic EMC Publications
60364-3-3.2, Amd 2	
IEC 1000-4-3	1995, Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 3: Radiated, radio-frequency, electromagnetic field immunity test
60364-3-3.2, Amd 2	
IEC 1000-4-6	1995, Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 6: Immunity to conducted disturbances, induced by radio-frequency fields
60364-3-3.2, Amd 2	
IEC 1000-4-8	1995, Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 8: Power frequency magnetic field immunity test—Basic EMC Publication
60364-3-3.2, Amd 2	
IEC 1000-4-12	1995, Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 12: Oscillatory waves immunity test—Basic EMC Publication
60364-4-411.1.2	
IEC 742	1983, Isolating and safety isolating transformers—Requirements

Location and Number of Standard	Title
60364-4-41.2, Amd 1	
IEC 146-2	1974, Semiconductor convertors—Part 2: Semiconductor self-commutated convertors
60364-4-41.2, Amd 1	
IEC 536-2	1992, Classification of electrical and electronic equipment with regard to electric shock—Part 2: Guidelines to requirements for protection against electric shock
60364-4-41.2, Amd 1	
IEC 1201	1992, Extra-low voltage (ELV)—Limit values
60364-4-43, Amd 1	
IEC 60269-1	1986, Low-voltage fuses—Part 1: General requirements
60364-4-43, Amd 1	
IEC 60269-2	1986, Low-voltage fuses—Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application)
60364-4-43, Amd 1	
IEC 60269-3	1987, Low-voltage fuses—Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications)
60364-4-43, Amd 1	
IEC 60724	1984, Guide to the short-circuit temperature limits of electric cables with a rated voltage not exceeding 0, 6/1, 0 kV
60364-4-43, Amd 1	
IEC 60898	1995, Electrical accessories—Circuit-breakers for overcurrent protection for household and similar installations
60364-4-43, Amd 1	
IEC 60947-2	1995, Low-voltage switchgear and controlgear—Part 2: Circuit-breakers
60364-4-442.1.4	
IEC 479-1	1984, Effects of current passing through the human body—Part 1: General aspects—Chapter 1: Electrical impedance of the human body—Chapter 2: Effects of alternating current in the range of 15 Hz to 100 Hz—Chapter 3: Effects of direct current
60364-5-510.2	
IEC 60073	1991, Coding of indicating devices and actuators by colors and supplementary means
60364-5-510.2	

Location and Number of Standard	*Title*
IEC 60447	1993, Man-Machine Interface (MMI)—Actuating principles
60364-5-510.2	
IEC 60617	Graphic symbols for diagrams
60364-5-510.2	
IEC 60707	1981, Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an ignition source
60364-5-510.2	
IEC 60750	1993, Item designation in electrotechnology
60364-5-510.2	
IEC 61024-1	1990, Protection of structures against lightning—Part 1: General principles
60364-5-510.2	
IEC 61082	Preparation of documents used in electrotechnology
60364-5-520.2	
IEC 332-1	1979, Tests on electric cables under fire conditions—Part 1: Tests on a single vertical insulated wire or cable
60364-5-520.2	
IEC 332-3	1992, Tests on electric cables under fire conditions—Part 3: Tests on bunched wires or cables
60364-5-520.2	
IEC 439-2	1987, Low-voltage switchgear and controlgear assemblies—Part 2: Particular requirements for busbar trunking systems (busways)
60364-5-520.2	
IEC 529	1989, Degrees of protection provided by enclosures (IP Code)
60364-5-520.2	
IEC 614	Specification for conduits for electrical installations
60364-5-520.2	
IEC 1200-52	1993, Electrical installation guide—Part 52: Selection and erection of electrical equipment—Wiring systems
60364-5-523.1.2	
IEC 287	Calculation of the continuous current rating of cables
60364-5-523.1.2	
IEC 502	Extruded solid dielectric insulated power cables

Location and Number of Standard	Title
60364-5-527.2.1	
ISO 834	Fire resistance tests—elements of building construction
60364-5-53.2	
IEC 269-3	1987, Low-voltage fuses—Part 3: Supplementary requirements for fuses for use by unskilled persons
60364-5-53.2	
IEC 1008	1990, Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses
60364-5-53.2	
IEC 1009	1991, Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses
60364-5-534.1.2	
IEC 60664-1	1992, Insulation coordination for equipment within low-voltage systems—Part 1: Principles, requirements, and tests
60364-5-534.1.2	
IEC 61312-1	1995, Protection against lightning electromagnetic impulse—Part 1: General principles
60364-5-534.1.2	
IEC 61643-1	1998, Surge-protective device connected to low-voltage power distribution systems—Part 1: Performance requirements and testing methods
60364-5-43.1.1	
IEC 79-8	[Obsolete document] Electrical apparatus for explosive gas atmospheres—Part 8: Classification of maximum surface temperatures
60364-5-548.1.2	
IEC 950	1991, Safety of information technology equipment
60364-5-548.1.2	
IEC 950, Amd 1	1992
60364-5-548.1.2	
IEC 950, Amd 2	1993
60364-6-61.2, Amd 1	
IEC 479-1	1984, Effects of current passing through the human body—Part 1: General aspects

Location and Number of Standard	***Title***
60364-6-61.2, Amd 1	
IEC 479-2	1987, Effects of current passing through the human body—Part 2: Special aspects
60364-7-701.53, Note	
IEC 669-1	Switches for household and similar fixed-electrical installations—Part 1: General requirements
60364-7-702.12	
IEC 60245-1	1994, Rubber insulated cables—Rated voltages up to and including 450/750 V—Part 1: General requirements
60364-7-702.12	
IEC 60245-4	1994, Rubber insulated cables—Rated voltages up to and including 450/750 V—Part 4: Cords and flexible cables
60364-7-702.12	
IEC 60536	1976, Classification of electrical and electronic equipment with regard to protection against electric shock
60364-7-702.12	
IEC 60598-2-18	1993, Luminaires—Part 2: Particular requirements—Section 18: Luminaires for swimming pools and similar applications
60364-7-702.12	
IEC 61140	1997, Protection against electric shock—Common aspects for installation and equipment (2nd edition)
60364-7-704.511.1	
IEC 439-4	1990-12, Low-voltage switchgear and controlgear assemblies—Part 4: Particular requirements for assemblies for construction sites (ACS)
60364-7-707, Preface	
IEC 83	1975, Plugs and socket-outlets for domestic and similar general use. Standards (Technical Report)
60364-7-707, Preface	
IEC 309-1	1979, Plugs, socket-outlets, and couplers for industrial purposes—Part 1: General requirements
60364-7-707, Preface	
IEC 435	1983, (Obsolete) Safety of data processing equipment
60364-7-707, Preface	
IEC 614-2-1	1982, Specification for conduits for electrical installations—Part 2: Particular specifications for conduits. Section 1—Metal conduits

Location and Number of Standard	***Title***
60364-7-708, Preface	
IEC 309-2	1981, Plugs, socket-outlets, and couplers for industrial purposes—Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories
60364-7-708, Preface	
IEC 695-2-1	1980, Fire hazard testing—Part 2: Test methods—glow-wire test and guidance
60364-7-708, Preface	
ISO 8818	1988, Leisure accommodation vehicles—caravans—12 V direct current extra low-voltage electrical installations
60364-7-709.12	
IEC 38	1983, IEC Standard Voltages
60364-7-709.12	
IEC 227	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
60364-7-711.1.2	
IEC 60204-1	1992, Electrical equipment of industrial machines—Part 1: General requirements
60364-7-711.1.2	
IEC 61046	1993, D.C. or a.c. supplied electronic step-down converters for filament lamps—General use and safety requirements
60364-7-714.12	
IEC 598	Luminaires

ANNEX B-2

U.S. PRODUCT REQUIREMENTS CORRESPONDING TO NORMATIVE REFERENCES IN IEC 60364 DOCUMENTS

Note: The indicated locations in IEC 60364 documents are in the order given in Annex B-1. The indicated corresponding U.S. product requirements were selected, taking into consideration the context in which the IEC documents were referenced.

	U.S. Product Requirements
Location and Number of Standard	***Number, Title***
60364-1-132.5	
IEC 721	UL50, Enclosures for Electrical Equipment
60364-3-3.2	
IEC 446	ANSI/NFPA 79, Electrical Standard for Industrial Machinery [contains requirements (among others) for identification of conductors]
60364-3-3.2, Amd 2	
IEC 255-22-1 IEC 801-4 IEC 1000 (all referenced parts)	UL991, Tests for Safety Related Controls Employing Solid-State Devices Note 1: UL991 includes EMC elements of EMC evaluations contained in IEC 1000 documents. UL991 applies where referenced in a product standard, such as UL8730, which is harmonized with IEC 60730 on automatic electrical controls for household and similar use Note 2: All EMC emissions related requirements are contained in U.S. Federal Regulations
60364-4-411.1.2	
IEC 742	UL1310, Class 2 Power Units UL1585, Class 2 and Class 3 Transformers UL1561, Dry-Type General Purpose and Power Transformers
60364-4-41.2, Amd 1	
IEC 146-2	UL508C, Power Conversion Equipment
60364-4-43, Amd 1	
IEC 60269-1, -2, -3	UL248 (series), Low-Voltage Fuses Note: A series of 16 Standards. UL/CSA harmonized

U.S. Product Requirements

Location and Number of Standard	*Number, Title*
60364-4-43, Amd 1	
IEC 60898 IEC 60947-2	UL489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
60364-5-510.2	
IEC 60707	UL94, Test for Flammability of Plastic Materials for Parts in Devices and Appliances
60364-5-510.2	
IEC 61024-1	UL96A, Installation Requirements for Lightning Protection Systems
60364-5-510.2	
IEC 332-1	UL910, Test for Cable Flame-Propagation and Smoke-Density Values
60364-5-510.2	
IEC 332-3	UL1685, Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables
60364-5-510.2	
IEC 439-2	UL857, Busways and Associated Fittings UL870, Wireways, Auxiliary Gutters, and Associated Fittings
60364-5-510.2	
IEC 529	UL50, Enclosures for Electrical Equipment (protection against environmental conditions only)
60364-5-510.2	
IEC 614 IEC 1200-52	UL1, Flexible Metal Conduit UL6, Rigid Metal Conduit UL360, Liquid-Tight Flexible Steel Conduit UL651, Schedule 40 and 80 Rigid PVC Conduit UL651A, Type EB and A Rigid PVC and HDPE Conduit UL1242, Intermediate Metal Conduit UL1660, Liquid-Tight Flexible Nonmetallic Conduit UL1684, Reinforced Thermosetting Resin Conduit UL797, Electrical Metallic Tubing UL1653, Electrical Nonmetallic Tubing
60364-5-523.1.2	
IEC 502	UL1072, Medium-Voltage Power Cables
60364-5-527.2.1	
ISO 834	UL1479, Fire Tests of Through-Penetration Firestops

U.S. Product Requirements

Location and Number of Standard	*Number, Title*
60364-5-53.2	
IEC 269-3	UL248 (series), Low-Voltage Fuses
60364-5-53.2	
IEC 1008 IEC 1009	UL489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures UL943, Ground-Fault Circuit-Interrupters
60364-5-534.1.2	
IEC 60664-1	UL840, Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment
60364-5-548.1.2	
IEC 950, Amds 1 & 2	UL1950, Standard for Safety for Information Technology Equipment
60364-7-701.53, Note	
IEC 669-1	UL20, General-Use Snap Switches
60364-7-702.12	
IEC 60245-1, -4	UL44, Thermoset-Insulated Wires and Cables UL62, Flexible Cord and Fixture Wire UL676, Underwater Lighting Fixtures
60364-7-704.511.1	
IEC 439-4	UL231, Power Outlets
60364-7-707, Preface	
IEC 83	UL1681, Wiring Device Configurations ANSI/NEMA WD 6, Wiring Devices—Dimensional Requirements UL1682, Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type UL1686, Pin and Sleeve Configurations
IEC 614-2-1	UL6, Rigid Metal Conduit
60364-7-708, Preface	
IEC 309-1	UL1686, Pin and Sleeve Configurations
IEC 309-2	ANSI/NFPA 501C, Recreational Vehicles
IEC 695-2-1	UL746, Polymeric Materials—Short Term Property Evaluations
60364-7-709.12	
IEC 38	ANSI C 84.1, Electric Power Systems and Equipment—Voltage Ratings (60 Hz)
IEC 227	UL83, Thermoplastic Insulated Wires and Cables

U.S. Product Requirements

Location and Number of Standard	*Number, Title*
60364-7-711.1.2	
IEC 60204-1	ANSI/NFPA 79, Electrical Standard for Industrial Machinery
	UL508, Industrial Control Equipment
IEC 61046	UL2108, Low-Voltage Lighting Systems (under consideration)
60364-7-714.12	
IEC 598	UL1570, Fluorescent Lighting Fixtures
	UL1571, Incandescent Lighting Fixtures
	UL1572, High Intensity Discharge Lighting Fixtures

ANNEX C

EXCERPTS FROM ISO/IEC DIRECTIVES, PART 3, 1997

6.5.1 Notes and examples integrated in the text

Notes and examples integrated in the text of a standard shall only be used for giving additional information intended to assist the understanding or use of the standard and shall not contain provisions to which it is necessary to conform in order to be able to claim compliance with the standard.

6.6.1 Verbal forms for the expression of provisions

6.6.1.1 A standard does not in itself impose any obligation upon anyone to follow it. However, such an obligation may be imposed, for example, by legislation or by a contract. In order to be able to claim compliance with a standard, the user needs to be able to identify the requirements he is obliged to satisfy. He needs also to be able to distinguish these requirements from other provisions where he has a certain freedom of choice.

6.6.1.2 Clear rules for the use for verbal forms (including modal auxiliaries) are therefore essential.

6.6.1.3 Annex E gives, in the first column of each table, the verbal form that shall be used to express each kind of provision. The equivalent expressions given in the second column shall be used only in exceptional cases when the form given in the first column cannot be used for linguistic reasons.

(ANNEX C continued)

VERBAL FORMS FOR THE EXPRESSION OF PROVISIONS OF ISO/IEC DIRECTIVES, PART 3, 1997 (NORMATIVE)

Note: Only singular forms are shown.

The verbal forms shown in the Requirement Table shall be used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted.

Requirement

Verbal form	***Equivalent expressions for use in exceptional cases (see 6.6.1.3)***
Shall	is to is required to it is required that has to only…is permitted it is necessary
shall not	is not allowed [permitted] [acceptable] [permissible] is required to be not is required that…be not is not to be
Do not use "must" as an alternative for "shall." (This will avoid any confusion between the requirements of a standard and external statutory obligations.) Do not use "may not" instead of "shall not" to express a prohibition. To express a direct instruction, for example, referring to steps to be taken in a test method, use the imperative mood in English. EXAMPLE: "Switch on the recorder."	

The verbal forms shown in the Recommendation Table shall be used to indicate that among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

Recommendation

Verbal form	*Equivalent expressions for use in exceptional cases (see 6.6.1.3)*
Should	it is recommended that ought to
Should not	it is not recommended that ought not to
In French, do not use “devrait” in this context.	

ANNEX D

EXAMPLE CIRCUITS

The following two example circuits are typical of circuits installed in one-or two-family dwellings in the U.S. The circuits are *NEC* compliant. These examples were analyzed by David Latimer, chairman of IEC TC64, which is responsible for IEC 60364. Latimer's analysis follows each of the two examples.

Additional commentary on the analysis is provided from the U.S. perspective.

Example No. 1

Central Air Conditioner (outdoor section) consisting of a hermetic motor compressor with inherent overload protection and a fan motor (thermally protected). [Sec. 440-52]

	Applicable ***NEC* Section**
Ratings	
Voltage: 230V, 1-ph, 60Hz (115V to ground)	250-20(b), 440-4
Supply System: Type TNS	250-20(b)
Compressor: 26.9A—Rated Load Amperes (RLA)	440-4
156.0A—Locked Rotor Amperes (LRA)	440-4
Fan: 1.4A—Full Load Amperes (FLA)	440-4
Marked Minimum Circuit Ampacity (MCA): 35A	440-33
[MCA = 1.25 RLA + FLA]	
Marked Maximum Fuse Size: 50A	440-22
Note: Fuse Rating could be 60A, per UL1995; manufacturer chose 50A	

Location:

Outdoor, 1 m from building; unit provides physical protection for wiring to fused switch

Wiring System, Unit to Switch:	T310-13, 351-4
Type THWN conductors in liquidtight flexible nonmetallic conduit in free air	
Conductors: 2 circuit conductors, No. 10 AWG	T310-16
1 protective earthing (grounding), No. 10 AWG	250-122
Insulation: 0.020 in. PVC plus 0.004 in. Nylon, rated 75°C	
Conductor properties: No. 10 AWG = 10380 cmils	Chapter 9, Table 8
(1975 cmil = 1 mm²)	
DC resistance = 1.24 ohms / 1000 ft.	Chapter 9, Table 8

Conduit: App. Chapter, Table C5

Liquidtight flexible nonmetallic conduit (Type B),
3/8 in. trade size, 0.494 in. ID, 1.2 m long

Fused Switch:

Rated 60A, 240V ac	440-12, 440-14
Fuse: 50A, Class RK5, nonrenewable cartridge type	
Between threshold and 50 kA: Ip = 20 kA, max.	
I^2t = 200,000 A^2s, max. (based on certification information)	

Wiring System, Switch to Panelboard: T310-16

Cable: Consists of 2 Type THWN, No. 10 AWG conductors in steel armor (Type AC Cable), 2 in. thermal insulation on each side (in wall) Total length 60 ft.	
Armor serves as protective earthing conductor	250-118
Maximum DC resistance of armor: 1.38 ohms per 75 m (based on UL4)	

Overcurrent Protection in Panelboard:

50A circuit breaker	440-22
Available short-circuit current: 20 kA	

Analysis of Example No. 1 Under Rules of IEC 60364

Example No. 1: Air Conditioner Unit

Ampacity of cables 35A

Circuit breaker rating 50 amps. Cables not protected against overload, but A/C unit has built-in overload protection. The separate overload and short-circuit protection rules can be invoked. We need to know the I^2t of the CB, which I do not have, but a rule of thumb is that a protective device protects a cable with an ampacity of half the rating of the CB. Therefore, this is probably satisfactory.

There is a need to calculate the Earth Fault Loop Impedance (EFLI) and thus the I^2t from the fuse or CB characteristics.

Fuse to A/C:

EFL formed by two 10 AWG wires
Resistance: 2 x 1.24 / k ft.
Length: 4 ft.
Resistance: 2 x 1.24 x 4 / 1000 = 0.01 ohms

CB to Switch:

EFL formed by 10 AWG wire and armouring
Resistance of armouring:
1.38 ohms / 75 M = 1.38 x 1000 / 75 / 3.28 = 5.6 ohms / 1000 ft.
Length: 60 ft.
EFL resistance: (5.6 + 1.24) x 60 / 1000 = .41 ohms
External loop impedance (assumed): 0.3 ohms
[External loop impedance is the impedance from the supply service to the service equipment. This impedance, plus the impedances of the live conductor up to the point of fault and the protective conductor from the fault to the service, comprises the Earth Fault Loop Impedance]
Total EFLI: 0.01 + 0.41 + 0.3 = 0.72 ohms
EF current: 115 / 0.72 = 161 A
Disconnecting time (fuse): 20 seconds
Disconnecting time (CB): 3–12 seconds

Permitted disconnecting time is five seconds, therefore the circuit does not comply if the CB is at the top limit of its characteristic; in actual fact, it would probably comply because manufacturers usually make to the lower edge of the characteristic.

Load current: 26.9 + 1.4 = 28.3
Circuit resistance: 1.24 x 2 x 63 / 1000 = 0.156
Voltage drop: 0.156 x 28.3 = 4.42 V = 1.92%

Note 1: The fuse does not discriminate against the CB.
Note 2: Because there is no discrimination, the whole circuit is protected against earth fault by the CB, so we must check its tripping time using the EFLI for the whole circuit. In this case, the fuse to A/C unit is so short that the difference between the EFLI of the whole circuit and that of the circuit from the CB to the fuse is negligible insofar as its effect on the tripping time is concerned. But if the difference in the EFLI was greater and there was discrimination, then it would be possible to ascertain the tripping time for a fault on the CB to fuse section of the circuit.

Maximum touch voltage: (5.6 x 60 / 1000 + 0.15) / 0.72 x 115 = 78 V

Example No. 2: Kitchen and Dining Room Receptacle Circuit

	Applicable *NEC* Section
Ratings	
Voltage: 20A, 120V, 60Hz, one side grounded	210-6, 210-52(b)
Overcurrent Protection: 20A circuit breaker	240-3(d)
Supply System: TNS	250-20(b)
Calculated Load: 1500 VA	220-16
Receptacles: 4-duplex in kitchen	
5-duplex in dining room	
Shock Hazard Protection	210-8
All kitchen receptacles protected by a receptacle type ground-fault circuit-interrupter (4-6 mA); dining room receptacles not protected by a GFCI	
Cable	
Type NM	
2 Type THHN, No. 12 Cu conductors; 1 bare No. 12 grounding (earthing) conductor in PVC Jacket	T310-16, 240-3(d), 250-122
Conductors	T310-13; Chapter 9, Table 8
No. 12 AWG THHN (0.015 in PVC + 0.004 in. Nylon) [No. 12 Cu = 6530 cmils (1975 cmils = 1 mm²), DC resistance - 1.98 ohms / 1000 ft.]	
Installed in uninsulated 10 cm wide wall cavities, through centers of wood studs	336-4
Wall surfaces: 1/2 in. gypsum wallboard	
Total length of circuit: 75 ft.	

Analysis of Example No. 2 Under Rules of IEC 60364

Example No. 2: Kitchen and Dining Room Receptacle Circuit

Load: 1500 VA (assessed) There are no rules in IEC as to how this is done; it is done differently in different countries
Current: 12.5A
Cable: 12 AWG
Ampacity: 25 A [Limited to 20 A by Sec. 240-3(d)]
Length: 75 ft.
Earth Fault Loop (EFL) formed by two 12 AWG wires
Resistance of 12 AWG: 1.98 ohms / k ft.
Earth Fault Loop Impedance (EFLI) of wires: 2 x 1.98 x 75 / 1000 = 0.3 ohms
External EFLI (assumed): 0.3 ohms

EF current: 120 / 0.6 = 200A
Disconnecting time for type 730-3 CB: 0.4 seconds max
Permitted disconnecting time at 120 V: 0.8 seconds

Therefore, the circuit complies.

Load current: 12.5 A
Circuit resistance: 0.3 ohms
Voltage drop: 0.3 x 12.5 = 3.75 = 3.26%

These disconnecting times are based on characteristics supplied by manufacturers.

Commentary on Analysis of Example Circuits

General: Comments in the analysis of Example No. 1 indicate that where separate overload and short-circuit protective devices are provided, which is the case in this example, short-circuit protection can be provided by a device with a rating of twice that of the ampacity of conductors ("rule of thumb"). Under the *NEC* hermetic motor compressors may be protected at up to 225% of the motor rated-load current. Since the ampacity of the conductors has to be at 125% of the RLA, the 2x rule of thumb is not exceeded. However, short-circuit and ground-fault protection at higher levels is permitted for other types of motors under Art. 430 of the *NEC*.

Considerable amount of information is needed under the IEC 60364 rules for installations that may be considered routine under the *NEC*.

Information is needed to be able to calculate the Earth Fault Loop Impedance (EFLI) which includes the service conductors, any feeders (distribution circuits), branch circuits (final circuits), and equipment ground return paths, such as conduit, cable armor, or equipment grounding (protective) conductors. From these values and the circuit voltage to ground maximum earth fault current is calculated. This current is then related to overcurrent device trip curves from which the disconnecting times are determined. The disconnecting time is an indication of the length of time during which hazardous voltages exist on electrical equipment.

The disconnecting times so calculated are valid only for a bolted fault at the assumed fault location—whether at a socket outlet or terminals of current-using equipment. If there is an arcing fault, there is an approximate 40 V arc-voltage drop, which reduces the earth fault current. Also, if extraneous metal bridges a phase conductor and an earthed part, the EFLI will be higher. In either case, the disconnecting time calculations are no longer valid and longer disconnecting times are very likely.

The foregoing calculations are made over a concern for protection against shock hazard due to indirect contact as specified in Sec. 413 and Clause 533.3. The potential shock hazard voltages exist on accessible metal parts only for the duration of the fault condition and only until the OC device opens the circuit. Normally persons do not remain in contact with exposed metal parts of fixed or stationary equipment for extended periods of time. Therefore, there is potential for shock hazard only if a person happens to be in contact with the equipment during the existence of the shock hazard voltage.

In situations where it is necessary for a person to be in contact with electrical equipment such as industrial machinery, other means of protection against electric shock are specified by IEC Standards as well as *NEC* and other NFPA documents. Likewise, at swimming pools and locations where persons are immersed in water, other measures of protection, e.g. GFCIs under the *NEC* and RCDs under IEC 60364, and stringent bonding rules are specified.

The concern over protection against indirect contact is appropriate if a hazardous touch voltage exists between simultaneously accessible conductive parts. Clause 413.1.1.1 indicates this voltage to be 50 V ac or higher. Ostensibly, where the possible touch voltages are lower, there should be no concern over the disconnecting times. Yet the second paragraph of 413.1.1.1 and 413.1.3.5 indicates that disconnecting times not exceeding five seconds, irrespective of the touch voltage, are permitted for distribution (feeder) circuits and final (branch) circuits supplying stationary equipment only. (Table 41A specifies disconnecting times between 0.8 and 0.1 seconds for circuits at 120 to over 400 V for circuits with socket outlets.) It is not clear why, from a shock hazard standpoint, the disconnecting time is significant when a hazardous voltage is not present.

Example No. 1

The TC64 Chairman's analysis indicates a touch voltage of 78 V, therefore, under the IEC rules, the disconnecting time calculations have been made. In the analysis, an external (service) loop impedance of 0.3 ohms has been assumed. It appears that this assumption has been influenced by the characteristics of European supply systems. Typically in the U.S., residences with a central air conditioner are provided with a 200 A service.

Even if the service conductors were 100 ft. (30.5 m) long, the external loop impedance would be only 0.019 ohms (2/0 cu conductors, 0.0967 ohms / k ft.). Using this value in the analysis, the total EFLI for the A/C circuit becomes 0.439 ohms and the EF current becomes 262 A (238 A if a 100 A service is assumed). A review of fuse and CB characteristics shows that the disconnecting times would be within five seconds.

Note 2 in the analysis addresses discrimination between the fuse and the circuit breaker. In the U.S. the vast majority of branch circuits have overcurrent protection is provided by circuit breakers. In this example the fuses provide protection for the equipment. In some cases, equipment markings specify fuse protection. [In other cases specially marked (HACR) circuit breakers may be used if the equipment markings so permit.] Coordination between the two types of OC devices is not necessary because each serves a different purpose.

Example No. 2

The analysis points out that load calculation (assessment) is not covered by IEC rules, but different countries address it differently. Other than ampacity of the conductors and the rating of the OC device, the calculated load has no effect on the remainder of the example.

In this case, the EFLI is calculated to the last socket outlet on the circuit. Provision of GFCI protection (4-6 mA) for the kitchen socket outlets means that the kitchen part of the circuit is protected from shock hazard due to indirect contact. Assuming a circuit length of 50 ft. to the last dining room socket outlet (no GFCI protection) and a fault at the last dining room outlet, the earth fault current would be approximately 240 A. The 20 A circuit breaker would function in even less than 0.4 seconds, judging from the information for the quoted 730-3 circuit breaker and known performance of U.S. circuit breakers.

If the circuit in this example is connected to the same distribution panelboard as the circuit in Example No. 1, and the service is rated 200 A, the external (service) loop impedance would also be lower than 0.3 ohms, and the EF current would be much higher. Shorter yet disconnecting times would be encountered.

ANNEX E

COMPARISON OF CONDUCTOR AMPACITIES

In the "Comparison of Significant Provisions, *NEC* to IEC 60364," the discussion under Sec. 310-15 contains an example where the conductor ampacities appear to be relatively equivalent. A closer analysis reveals that overall the *NEC* ampacities are more conservative, especially when the difference in the conductor insulation temperature rating is taken into consideration. One of the standard conductor temperature ratings is 75°C in the *NEC*, whereas in Part 5, Sec. 523 of IEC 60364, the closest standard rating to 75°C is 70°C. If the *NEC* ampacities were recalculated for a 70°C maximum temperature, the allowable ampacities would be lower yet.

Tables E-1 and E-2 contain the ampacities given in the respective documents. Figure E1 depicts the difference.

Table E.1

Allowable Ampacities of Insulated Conductors Rated 0-2000 V, 75°C, Not More Than Three Current-Carrying Conductors in a Raceway or Cable, Based on Ambient Temperature of 30°C

Excerpt from NEC, Table 310-16

Copper Conductors, 75°C

AWG or kcmil	mm²	Allowable Ampacities, Amperes
14	2.08	20
12	3.31	25
10	5.26	35
8	8.37	50
6	13.30	65
4	21.15	85
2	33.62	115
1/0	53.49	150
4/0	107.20	230
700	355.00	460

Table E.2

Current-carrying capacities in amperes for cables in free air, with clearance from wall not less than 0.3 times cable diameter, conductor temperature 70°C, ambient temperature 30°C, three loaded copper cores.

Excerpt from Table 52-C9, Column 2

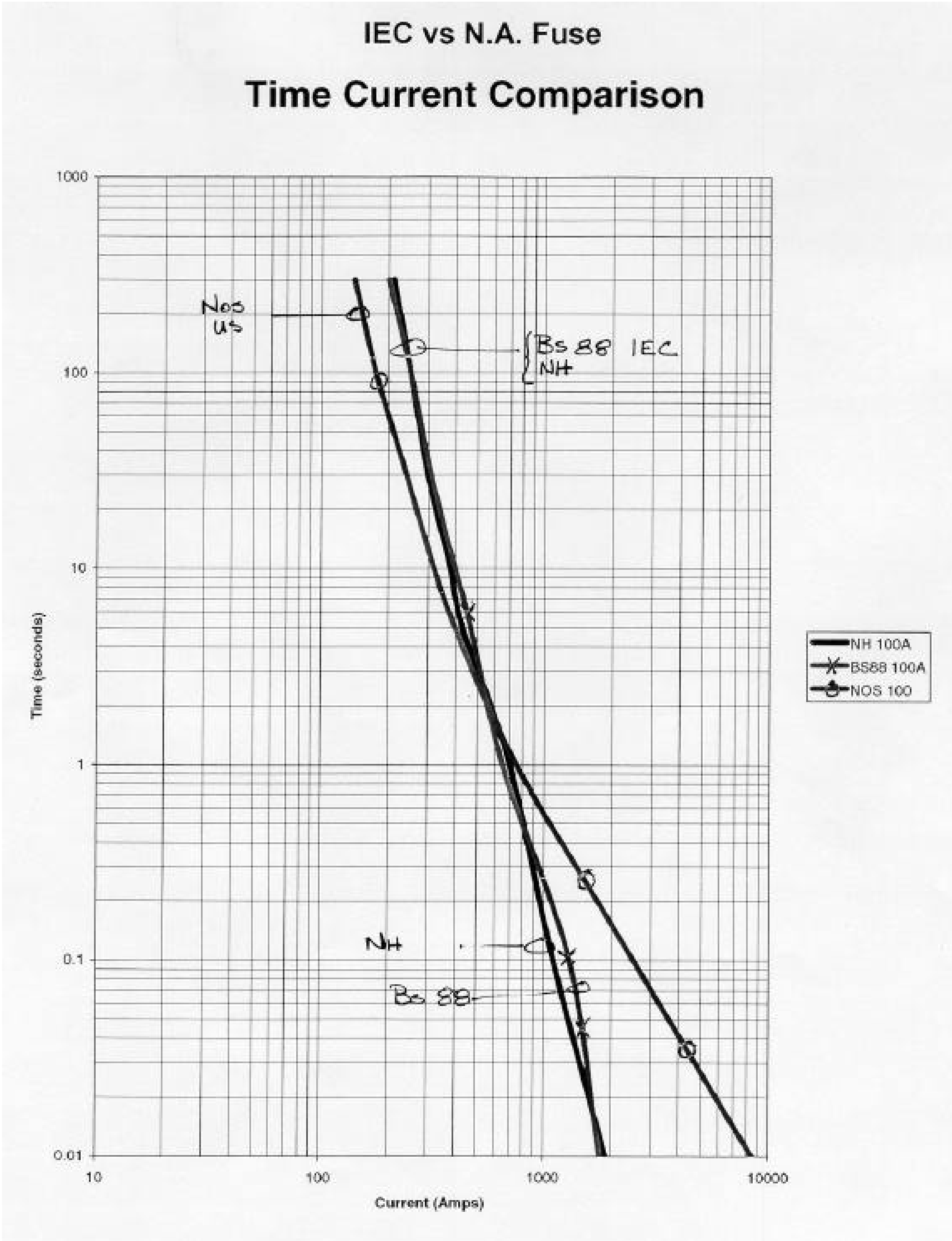
Nominal cross-sectional area of conductor, mm²	***Current-carrying capacity, amperes***
1.5	18.5
2.5	25.0
6.0	43.0
10.0	60.0
16.0	80.0
35.0	126.0
70.0	196.0
240.0	430.0
300.0	497.0

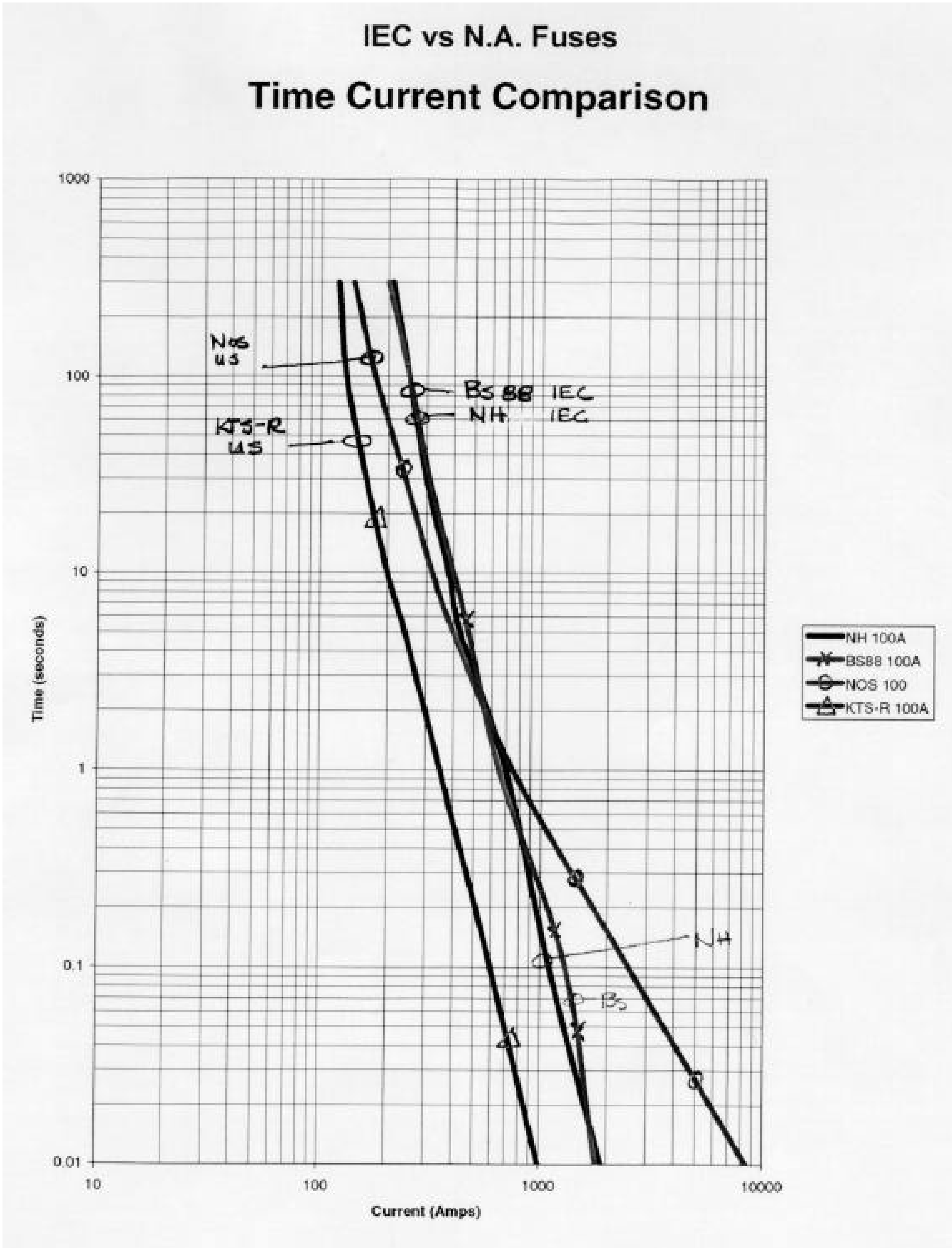
ANNEX F

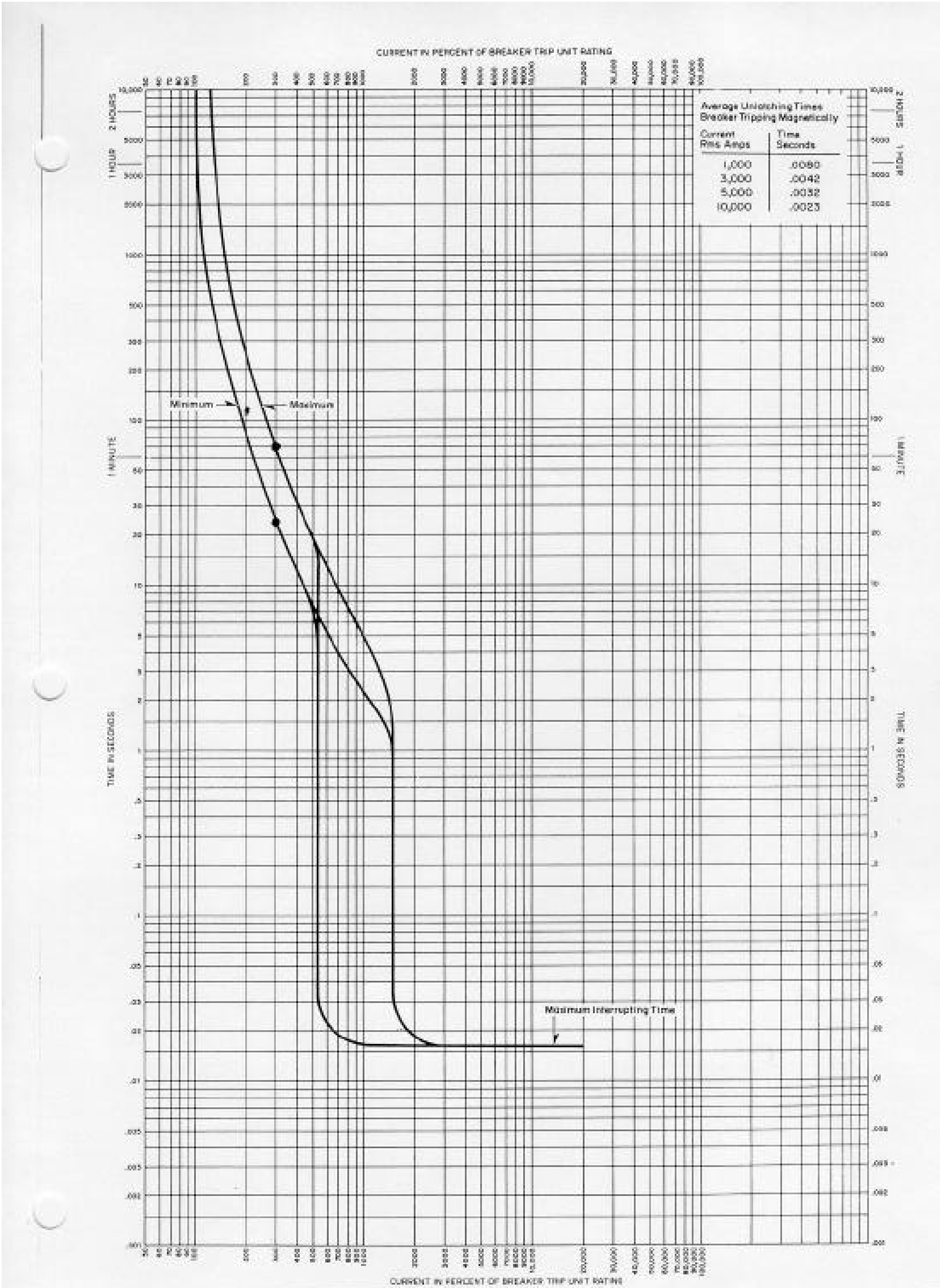
FUSE AND CIRCUIT BREAKER CHARACTERISTICS

In the following fuse time vs. current characteristic graphs, the BS88 and NH fuses are IEC fuses. The NOS and KTS-R fuses are U.S. fuses. Notable is the delay at higher current values for the NOS fuse.

The circuit breaker characteristics are typical of molded-case circuit breakers built to North American standards.


IEC vs N.A. Fuse
Time Current Comparison
Time (seconds)
Current (Amps)
1000
100
10
1
0.1
0.01
10
100
1000
10000
NH 100A
BS88 100A
NOS 100
Nos US
Bs 88 IEC
NH
NH
Bs 88


IEC vs N.A. Fuses
Time Current Comparison
Time (seconds)
1000
100
10
1
0.1
0.01
10
100
1000
10000
Current (Amps)
NH 100A
BS88 100A
NOS 100
KTS-R 100A
NOS US
KTS-R US
BS 88 IEC
NH IEC
NH
BS



typical molded case circuit-breaker time-current curve

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