

Introduction and History

The intent of this book is to provide training material and resources for students and to assist those involved with designing, installing, inspecting and maintaining electrical systems in hazardous (classified) locations. It includes information on area classification, methods of protection, interaction of protection techniques with specific types of electrical equipment, wiring requirements, and on specific occupancies and industries.

The study of any subject related to the *National Electrical Code* should include a basic review of Article 90. The purpose of the *NEC* as stated in 90.1 is “the practical safeguarding of persons and property from hazards arising from the use of electricity.” Therefore, everything in chapter 5 of that document should relate to that purpose.

Scope of the Code

The scope of the *NEC*, in 90.2, is to provide guidance on what is covered by the *Code*. Not all of the electrical hazards associated with hazardous (classified) locations are within its scope. This book, although primarily concerned with proper application of the *Code*, will also include information related to electrical safety that is outside the scope of the *NEC*. A basic understanding of such information located in other standards and of recommended practices is critical to properly applying the requirements and concepts covered by the *NEC*. Since many *NEC* users do not have ready access to those documents, this book will provide applicable information and proper references to specific requirements in other documents and resources to assist in proper applications.

Arrangement of the Code

The arrangement of the requirements in the *NEC* is critical to proper application of those requirements and is covered in 90.3, which reads: “This *Code* is divided into the introduction and nine chapters, as shown in Figure 90.3. Chapters 1, 2, 3, and 4 apply generally; Chapters 5, 6,

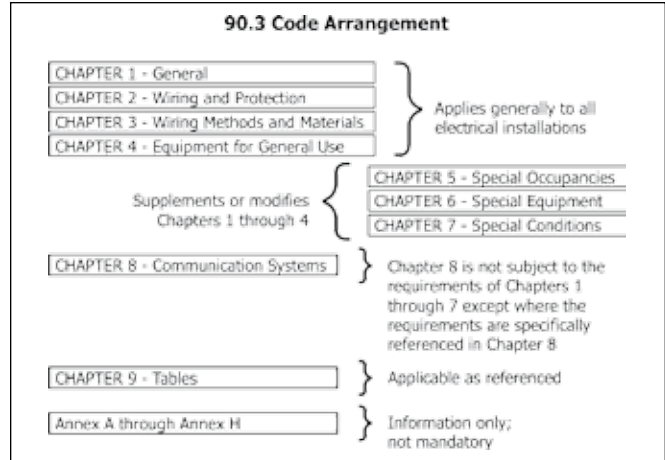


Figure 1. Code Arrangement (Reproduction of *NEC* Figure 90.3) and 7 apply to special occupancies, special equipment, or other special conditions. These latter chapters supplement or modify the general rules. Chapters 1 through 4 apply except as amended by Chapters 5, 6, and 7 for the particular conditions (see figure 1).

“Chapter 8 covers communications systems and is not subject to the requirements of Chapters 1 through 7 except where the requirements are specifically referenced in Chapter 8.

“Chapter 9 consists of tables.”

When 90.3 is applied to an installation related to a hazardous (classified) location, it is obvious that all of the general requirements of chapters 1 through 4 of the *NEC* apply, unless they are modified by the special occupancy requirements in chapter 5. Section 800.3(B) refers to applicable requirements in chapter 5 for communications circuits and equipment installed in hazardous (classified) locations.

Enforcement of Code

Enforcement is addressed in 90.4: “This *Code* is intended to be suitable for mandatory application by governmental bodies that exercise legal jurisdiction over electrical installations, including signaling and communications systems, and for use by insurance inspectors. The authority having jurisdiction for enforcement of the *Code* has the responsibility for

making interpretations of the rules, for deciding on the approval of equipment and materials, and for granting the special permission contemplated in a number of the rules.”

Readers should be aware that *approval of* and *design of* electrical installations in hazardous locations are two different tasks and responsibilities. Readers should also realize that the area classification part of design would likely include a design team rather than a single electrical design person. This design team could easily include electrical, process, mechanical, fire protection and structural design contributors. Area classification and design of the electrical system installed within that area is the responsibility of the owner’s representative(s), the design team. That design should include proper documentation. Approval of the classification and design is the responsibility of the AHJ. Proper application of the *NEC* requirements will necessitate everyone involved in the project working together for the installation to be effectively completed.

Common Language of Communication

An additional goal will be to collect and use defined terms to minimize confusion and to insure proper exchange of information. Some terms related to hazardous (classified) locations are found in the *NEC*, while others are found in other standards or documents. The term *hazardous (classified) location*, for example, as used in Articles 500–517, is “a location where fire or explosion hazards may exist due to flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors, flammable liquids, combustible dust, or ignitable fibers/flyings.” A review of other codes and standards reveals that *hazardous locations* include health hazards, flammability hazards, and instability hazards (see NFPA 704).

Another primary goal of this training material is to offer a systematic outline for the exchange of information related to electrical installations in hazardous (classified) locations. Such an approach will allow everyone involved in the process to realize that all applicable variables related to the project have been considered in order to minimize the chance of fires and

explosions being caused by the electrical system.

Approvals

The *Code* indicates that conductors and electrical equipment are acceptable only where approved by the authority having jurisdiction. This authority could be a federal, state, local or regional department, or an individual such as a fire chief, fire marshal, building official, electrical inspector, or others having statutory authority. Often, the AHJ bases approvals on the use of listed equipment. For electrical installations in hazardous (classified) locations, however, the approval process can involve utilizing other acceptable alternatives. The terms *approved*, *identified*, and *listed* are all used throughout the *Code* rules that apply to hazardous locations and the specific meaning of each should be understood for proper application.

Definitions

Approved means being acceptable to the authority having jurisdiction.

Identified, as applied to equipment, is being recognizable as suitable for the specific purpose, function, use, environment, application, and so forth, where described in a particular *Code* requirement.

“FPN: Some examples of ways to determine suitability of equipment for a specific purpose, environment, or application include investigations by a qualified testing laboratory (listing and labeling), an inspection agency, or other organizations concerned with product evaluation.”

Listed is when equipment, materials, or services are included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material, or services either meets appropriate designated 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” (Article 100).

History and Timeline

The following timeline indicates when and how *Code* requirements for hazardous (classified) locations evolved. This information, furnished by Underwriters Laboratories (UL), provides an idea of the evolution of key codes and standards related to hazardous (classified) locations.

1920s–1930s

In the early years, hazardous (classified) locations were referred to in the *NEC* as “extra hazardous locations.” Everything else regarding the use of electricity was considered to be hazardous, but for reasons of shock and fire, not for explosions. *NEC* rules addressed rooms or compartments in which highly flammable gases, liquids, mixtures or other substances were manufactured, used or stored. At that time, UL had been evaluating and certifying equipment for use in such areas for about two years. One of the first hazardous (classified) location requirements in the *NEC* was associated with inhalation of flammable gases for anesthetizing locations in health care facilities.

1931

Classifications of Class I materials, including gases and vapors, and Class II for dusts were defined and covered by the *NEC*. Also, Class III and Class IV locations were defined for fibers.

1935

Groups were first defined for Class I locations, based on explosive pressure and flame transmission. At this time the gases were designated into groups as follows:

- Group A—Acetylene
- Group B—Hydrogen or gases and vapors of equivalent hazard
- Group C—Ethyl ether or gases and vapors of equivalent hazard
- Group D—Gasoline, petroleum, naphtha, alcohol, acetone, lacquers, solvent vapors

1937

Groups for Class II locations were first defined and designated as follows:

- Group E—metal dusts
- Group F—coal and other carbonaceous dusts
- Group G—grain, wood, plastic, etc.

1947

The concept of the Division system was introduced to the *Code*. Classified locations were divided into separate divisions based on the degree of hazard involved. For Class I and Class II locations, Divisions 1 and 2 locations were designated. At this time Classes III and IV were combined into Class III locations.

1960

Underwriters Laboratories developed Westerberg Explosion Test Vessel (WETV), which was designed to determine two quantities for any gas or vapor, and flame transmission properties by measuring the maximum experimental safe gap (MESG) under explosion pressure.

The WETV was, and still is, used to determine certain explosion characteristics of gases and vapors. The chamber is equipped with two blocks of metal that can be adjusted to obtain air gaps between them; by igniting the gas in the first chamber it may ignite the gas in the second chamber after passing through the metal-to-metal gapped joint (see photos 1 and 2). The largest clearance that will not allow passage of flame is called the MESG. The WETV data enables classification of gases and vapors into defined groups by comparing the MESG and explosion pressure to those of materials already defining the group.

1969

UL published *Bulletin of Research* No. 58. This bulletin summarized a UL investigation of fifteen flammable gases or vapors based on WETV test data. The materials (groups) were added to *NEC*-1971. The International Electrotechnical Commission published IEC 79-1A that defines a different type of apparatus to classify gases and vapors, based on MESG only.

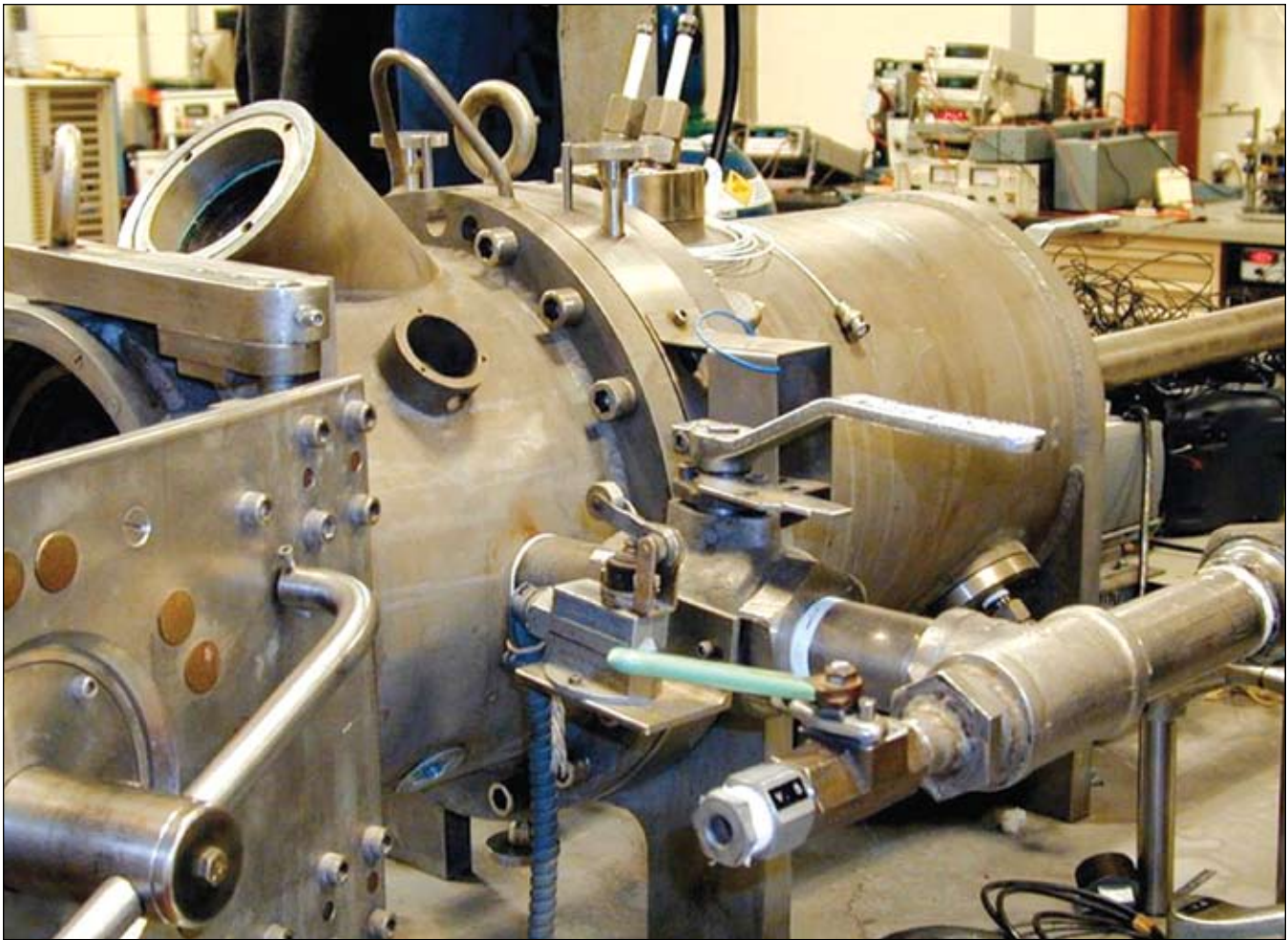


Photo 1. Westerberg Explosion Test Vessel (WETV) Courtesy of Underwriters Laboratories Inc.



Photo 2. Westerberg Explosion Test Vessel (inside view) Courtesy of Underwriters Laboratories Inc.

Autoignition temperature limits for group classification of gases and vapors were removed from the *NEC*. Equipment-operating temperatures, or “T codes,” were established. External temperatures of equipment in these locations cannot exceed autoignition temperature of material.

1970s

UL published *Research Bulletins* 58A and 58B. These bulletins summarize investigations of approximately 30 additional gases and vapors based on Westerberg Explosion Test Vessel data. These 30 additional gases and vapors were then added to *NEC-1978*.

1983

The National Fire Protection Association published NFPA 497M, *Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations*.

NFPA Standard 497M classified hazardous materials based on test data from the Westerberg Explosion Test

Vessel, and it was used to establish similarity to a tested material or chemical family.

1993

The maximum allowable temperature for Class II groups, which relied on comparing “T codes” and ignition temperatures of dusts was removed from the *NEC*.

1996

The International Zone Classification system was added to the *NEC* by including a new Article 505. This article covered Class I only and included three gas groups—IIC, IIB, and IIA. It also included three Zones—0, 1, and 2, which were comparable to the Division system with some small differences. Underwriters Laboratories began certifying equipment for use in areas classified under the IEC Zone classification system.

1997

NFPA combined their standards NFPA 497A, B, and M into two separate standards: NFPA 497 (for gases) and NFPA 499 (for dusts).

1999

Some new definitions of Class I groups were added in *NEC*–1999, based on the following information:

- Historical perspectives
- MESH data from WETV & IEC 79
- Minimum igniting current (MIC) ratio

Article 505 was also revised to introduce the IEC protection techniques and marking scheme.

2002

Article 505 was completely rewritten and restructured, making it independent of other articles.

2005

NEC–2005 clarified area classifications in the earth below a motor fuel dispensing facility and a commercial repair garage. These areas are unclassified due to the lack of air in those locations.

Articles 500 through 505 were restructured to provide a common numbering sequence between the articles; and a new Article 506 was added to provide an alternative method of addressing concerns for electrical installations where fire and explosion hazards may exist

due to combustible dusts, fibers and flyings. Article 506 did not provide any IEC protection techniques. The addition of Article 506 was a continuation of the efforts toward harmonization between the *NEC* and the IEC requirements for electrical installations in hazardous (classified) locations.

2008

The significant revisions to the *NEC*–2008 are:

In Article 501.10(B), uses permitted, in industrial locations with limited public access where qualified persons service the installation and where metallic conduit does not provide sufficient corrosion resistance, Schedule 80 PVC conduit and Type RTRC conduit, with their factory elbows and associated fittings, may be installed, if all conditions in the requirement are met.

In Article 501, flexible conduit and liquidtight flexible metal conduits will generally not be permitted to be used as an equipment grounding conductor in Class I, Division 1 and Division 2 locations without an additional bonding jumper is installed. Also, transformers and capacitors that do not contain a liquid that will burn must either be installed in vaults complying with 501.100(A)(1), or be identified for use in Class I locations.

In Article 504, single components in simple circuits that store energy, such as capacitors or inductors, are permitted to be included as part of an intrinsically safe system without evaluation by a qualified electrical testing laboratory. Also, seals for conduits and cables containing intrinsically safe circuit wiring are not required to be explosionproof or flameproof, but shall be accessible and identified for the purpose of minimizing passage of gases, vapors, or dusts under normal operating conditions.

In Article 505, Zone systems are now no longer required to be classified by a registered professional engineer, but the persons designing, installing and inspecting the installation must be *qualified*. See Article 100 for the definition of a *qualified person*.

Definitions of a *major repair garage* and *minor repair garage* were added to Article 511. As was the definition of *aircraft painting hangar* to Article 513. Area classifications have been added in 513.3.

IAEI intends to revise this work to complement each new edition of the *NEC*. Any suggestions for pertinent material or improvements would be welcome.