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IEEE Standard Power Cable Ampacity Tables

Sponsor

Insulated Conductors Committee
of the
IEEE Power Engineering Society

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Abstract: Over 3000 ampacity tables for extruded dielectric power cables rated through 138 kV and laminar dielectric power cables rated through 500 kV are provided.
Keywords: ampacity, cable, dielectric, extruded, laminar, power

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Foreword

(This foreword is not a part of IEEE Std 835-1994, IEEE Standard Power Cable Ampacity Tables.

The original edition of the "Current Carrying Capacity" tables was published by the Insulated Power Cable Engineers Association (IPCEA) in 1943. With the advent of new types of cables and better knowledge of thermal circuits, IPCEA decided, in 1954, that a new edition should be published. Since the AIEE Insulated Conductors Committee was interested in the subject, a joint AIEE-IPCEA working group was formed to handle the technical aspects. The members of this working group were J. H. Neher, Chair, F. H. Buller, R. W. Burrell, W. A. Del Mar, M. H. McGrath, E. J. Merrell, H. A. Schumacher and R. J. Wiseman. The financing of the computer programming and calculations was underwritten by IPCEA, now ICEA, while the AIEE (now the IEEE) assumed the publishing role for the 1962 version of the AIEE-IPCEA Ampacity Tables Standard. This standard, identified as AIEE S-135-1 and S-135-2 and IPCEA Publication P-46-426, served the industry well for the last 30 years.

From 1970 onward, the design and application of medium and high voltage cables underwent many changes. The use of medium voltage extruded dielectric cables grew tremendously in the United States and throughout many other industrialized countries. New insulating materials and improvements in the design and installation of underground cables were developed, creating a need for updating and expanding the original ampacity tables. Advances in computer technology could also be utilized to facilitate the work on new tables.

Because of continuing demand for upgraded tables, the IEEE Insulated Conductors Committee (ICC) was asked to undertake a project to meet this need. In the late 1970's, ICC formed a working group within the Cable Characteristics Subcommittee, Project 3-1, to prepare a document outlining the scope of work necessary to establish parameters, and to update the cable constructions and design changes that had taken place since the original publication. This would then lead to a revision and expansion of the ampacity tables. This document, P835, was prepared and subsequently approved by the ICC and the IEEE Standards Board in 1984. However, the large amount of computer time and work by experts in the field to compile the actual tables placed this project beyond the reach of the normal volunteer approach to creating IEEE standards. Thus, due to lack of funds, the project languished for several years.

In 1990, following a special meeting of the ICC officers and colleagues during the Winter Power Meeting in Atlanta, a new effort to resurrect this project was developed. This new effort included a drive to raise the necessary funds through contributions from companies and individuals who would benefit from the new tables. This was the first attempt ever to raise funds from IEEE members and companies to support a standard. Following IEEE approval, this drive was launched and was successful in meeting the project's financial needs. A letter ballot was circulated to ICC voting members in 1990 to reaffirm the scope of the project. After minor changes were made to resolve negative votes, the IEEE contracted for the needed services. Following completion of the initial tables, a team of volunteers was appointed to verify preliminary results through manual computations.

In addition to the Chair, Past Chair, and members of the Working Group (listed on the next page), other ICC members are deserving of special recognition in bringing this project to fruition. Roland Watkins, while ICC Chair in 1990 and 1991, was instrumental in reviving the project and instigating the successful fund raising effort. Past ICC Chairs E. Duffy, I. Berkhan, J. B. Gardner, B. Smith, and T. Balaska worked diligently during their terms, along with the past chairs of the Working Group, to solve the problems that were delaying the project. A special thanks is given to M. A. Martin, Jr., who fostered this project from its early beginnings in the late 1970's to its publication in 1994. Over this time period, he spent many volunteer hours educating the IEEE on the need for this project.

While it is the policy of the IEEE to not publicly recognize IEEE employees and paid professionals involved in the development of IEEE standards, it goes without saying that this document could not have been created without their dedicated effort. We must also document the use of commercial computer programs identified as USAMP and TRAMP in the compilation of these tables, although IEEE owns the copyright and assumes full responsibility for this publication.

The initial ground work by the original AIEE-IPCEA Working Group laid the foundation for ampacity tables in this IEEE standard. The IEEE sincerely appreciates the working relationship it has maintained with ICEA and the effort by ICEA members in the development of new tables.

Past and present members of the Working Group are as follows:

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IEEE also wishes to give a special thanks to the following individuals and organizations for their financial contribution to this venture. It was their dedication and effort that allowed this project to go forward.

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The scope of this standard was approved by the IEEE Standards Board on June 27, 1991. The IEEE Standards Board approved this standard on September 22, 1994, with the following membership:

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IEEE Standards Project Editor

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CLAUSE PAGE

Introduction to the Power Cable Ampacity Tables

1. Overview

1.1 Scope

This standard provides calculated ratings for the following cables:

Type 1: 600 V–5 kV unshielded extruded dielectric
Type 2: 5–15 kV two conductor shielded URD single phase extruded dielectric
Type 3: 5–46 kV single conductor extruded dielectric
Type 4: 69–138 kV single conductor, unfilled, crosslinked polyethylene
Type 5: 69–138 kV single conductor, filled crosslinked polyethylene and ethylene propylene rubber
Type 6: 5 kV and 15 kV three conductor extruded dielectric
Type 7: 5–35 kV single conductor paper insulated, lead sheathed
Type 8: 5–35 kV, three conductor, paper insulated, lead sheathed, shielded
Type 9: 69–500 kV, single conductor, self contained, paper insulated, liquid filled
Type 10: 69 kV, three conductor, self-contained, paper insulated, liquid filled
Type 11: 69–500 kV high pressure, paper insulated, liquid filled, pipe type
Type 12: 115–500 kV high pressure, laminated paper, polypropylene insulated, liquid filled, pipe type
Type 13: 69–138 kV high-pressure gas-filled, pipe type

Installation conditions include duct banks (as shown in figure 1), direct buried cables, cables buried in ducts, buried pipes, horizontal cable in ducts, in air and vertical non-vented riser cables. The various operating conditions for each of the cable designs and installation conditions are described in the technical features of the tables (clause 3).

1.2 Purpose

Over the past 30 years the AIEE S-135-1 and S-135-2 (IPCEA P-46-426) Power Cable Ampacities publications have often been referred to as the "black books" and have been used by engineers, planners, and system designers throughout the world. During this time period, these publications were the only complete document on power cable ampacities in the United States. In 1976, the Insulated Conductors Committee, in cooperation with the Insulated Cables Engineering Association (ICEA) and the National Electrical Manufacturers Association (NEMA), published supplemental ampacity tables to provide ampacity ratings for single conductor cables with shield losses due to circulating currents. That publication was needed due to the tremendous increase in the use of single conductor extruded dielectric cables with multiple point bonding and grounding.

As time passed, new cable designs were developed with synthetic insulation, different shielding designs and higher operating voltages and temperatures. Moreover, new technology and equipment was developed for measuring the thermal properties of soil. These developments with heat transfer in soils provided a different understanding and approach for rating cables based on maximum cable/earth interface temperature. In addition, new forced convection heat transfer analytical methods were employed for cables in air, which provided for less conservative ampacity ratings.

The tables in this standard reflect these changes in methodology and provide the user with a vast array of cable ampacity ratings for 600 V utilization cables, medium voltage distribution cable and high voltage transmission cables.

2. References

This standard shall be used in conjunction with the following references. Other related documents are listed as bibliographical items in clause 4.

AEIC CS4-93, Specifications for Impregnated-Paper-Insulated Low and Medium Pressure Self-Contained Liquid-Filled Cable.[1]

AEIC G1-68, Guide for Application of AEIC Maximum Insulation Temperatures at the Conductor for Impregnated-Paper-Insulated Cables.

ICEA P-45-482 (1979), Short Circuit Performance of Metallic Shielding and Sheaths.[2]

IEC 287 (1982), Calculation of the Continuous Current Rating of Cables (100% load factor).[3]

IEEE Std 738-1993, IEEE Standard for Calculating the Current Temperature of Bare Overhead Conductors (ANSI).[4]

NEMA WC50-1988/ICEA P-53-426, Ampacities, 15–69 kV 1/c Power Cable Including Effect of Shield Losses (Solid Dielectrics).[5]

3. Technical features of the tables

3.1 Parameters

The calculated ampacities in this standard are based on the parameters and assumptions discussed in the following subclauses.

3.1.1 Voltage

600 V–5 kV, 5 kV, 15 kV, 25 kV, 46 kV, 69 kV, 115 kV, 138 kV, 230 kV, 345 kV and 500 kV as indicated for each cable type.

3.1.2 Load and loss factors

Load factors of 75 and 100 percent (%) and corresponding loss factors 62.5 and 100 percent (%) for buried cable

3.1.3 Dielectric loss

The dielectric loss was computed based on the values of dissipation factor and dielectric constants listed below. The dielectric loss may have a significant effect on cable ampacity for multiple 15–35 kV cables in a duct bank or for some cables rated above 35 kV. However, in general, the dielectric loss is negligible for single circuit extruded dielectric cables rated up to 35 kV, unless the dissipation factor increases significantly with elevated operating temperatures.

[1] AEIC publications are available from the Association of Edison Illuminating Companies, 600 N. 18th Street, P. O. Box 2641, Birmingham, AL 35291-0992, USA.

[2] ICEA publications are available from ICEA, P.O. Box 411, South Yarmouth, MA 02664, USA

[3] IEC publications are available from IEC Sales Department, Case Postale 131, 3 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[4] IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[5] NEMA publications are available from the National Electrical Manufacturers Association, 2101 L Street NW, Washington, DC 20037, USA.