National Electrical Manufacturers Association
Capacitors Section

Scope and High-Level Outline of a Low-Voltage AC Capacitor Standard

Section 1: Scope

This document provides standard requirements and general guidelines for the design, performance, testing and application of low-voltage dry-type alternating current (AC) power capacitors rated 1,000V or lower, and for connection to low-voltage distribution systems operating at a nominal frequency of 50Hz or 60Hz.

This document does not pertain to low voltage oil-filled or direct current (DC) power capacitors.

Section 2: Normative References

IEC 60831-1, Shunt power capacitors of the self-healing type for AC systems having a rated voltage up to and including 1,000V – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation

IEC 60831-2, Shunt power capacitors of the self-healing type for AC systems having a rated voltage up to and including 1,000V – Part 2: Ageing test, self-healing test and destruction test

UL 810, Standard for Capacitors

CSA C22.2 No. 190, Capacitors for power factor correction

IEEE Std. 18-2012, IEEE Standard for shunt power capacitors

IEEE Std. 1531-2020, IEEE Guide for the application and specification of harmonic filters

IEEE Std. C37.99-2012, IEEE Guide for the protection of shunt capacitor banks

IEEE Std. 1036-2020, IEEE Guide for the application of shunt power capacitors

CIGRE TB 550, Lightning protection of low-voltage networks

NFPA 70, National Electric Code 2020 Edition

IEEE Std. 519-2014, IEEE Recommended practice and requirements for harmonic control in electric power systems

Section 3: Definitions, Acronyms, and Abbreviations

Section 4: Design Requirements

4.1 Capacitor internal design and construction
Description of internal materials, dielectric, insulation, metallization, winding methodology and filling agent.

4.2 Capacitor external design and construction
Description of external materials, terminals, case, and nameplates.

4.3 Capacitor Fusing
Description of capacitor fuses and fusing applications including:

a. Blown fuse indications

b. Series fusing
c. Parallel fusing

4.4 Discharge resistor
Description of internal discharge resistors, sizing methodology and connection.

4.5 Capacitor status indication and additional features
A brief description of capacitor status indication and additional capacitor features that may be offered.

Section 5: Performance and Rating Requirements

5.1 Service Conditions
Description of normal and abnormal service conditions, ambient conditions, and classification of capacitor types according to temperature ratings.

5.2 Typical voltage and reactive power (kvar) ratings for capacitor units.
A brief description of the nominal ratings (i.e. kvar, voltage, capacitance) that are typical of the low-voltage AC power capacitors of concern.

5.3 Capacitance tolerance (± % of μF and kvar)
Declaration of allowable manufacturing tolerances for each capacitor unit and each capacitor at nominal rated voltage and frequency.

5.4 Maximum overvoltage and overcurrent capabilities
Details and requirements of maximum over-voltage and over-current capabilities of capacitor units expressed as a function of time and specific application (e.g. power factory correction or harmonics mitigation).

5.5 Heat Losses and Dissipation
Description of the classification of temperature ratings, applications, heat losses and heat dissipation requirements.

5.6 Self-healing capability
Description of self-healing capabilities, operation, and consequences.

5.7 Application performance and rating requirements
A discussion on the following applications considerations:
a. Rated voltage vs. applied network voltage
b. Design applications of capacitors, i.e. fixed, power-factor correction, de-tuned designs, and harmonic filter capacitors
c. Inrush current calculations and considerations from energization
d. Back-to-back switching inrush current considerations
e. Other capacitor switching considerations

Section 6: Testing Requirements

6.1 Routine Tests – Voltage
Declaration of routine voltage tests applicable for capacitor units.

6.2 Routine Tests – Current
Declaration of routine current tests applicable for capacitor units.

6.3 Routine Tests – Discharge
Declaration of capacitor discharge testing application of capacitor units.

6.4 Design Tests – Self-healing
Description of self-healing test in accordance with IEC 60831-2.

6.5 Design Tests – Ageing
Description of ageing test in accordance with IEC 60831-2.

6.6 Design Tests – Destruction
Description of destruction test in accordance with IEC 60831-2.

6.7 Dielectric rigidity test voltage
Description of the process of dielectric rigidity test voltage value application of 1,000V plus 2 times nominal application voltage for 1 minute, OR 1,000V plus 2 times nominal application plus 20% margin for 1 second.

Section 7: Application guidelines and requirements

7.1 Power factor correction
Description of application of low-voltage power capacitors for power factor correction in distribution systems due to the var demand from asynchronous motors and other low power factor loads. Discussions on the consumption of reactive power based on motor power rating, loading, rated speed, motor NEMA design or otherwise.

7.2 Harmonic Mitigation
Description on the use of low-voltage power capacitors for harmonic filtering applications. Brief discussion on harmonic filter design and application. References to IEEE 1531 for further guidance. Brief discussion on overloading and over-rating requirements for harmonic mitigation applications.

7.3 Enclosure requirements
Description of enclosure design requirements as pertaining to insulation, clearance, degrees of protection and seismic requirements, in accordance with NEMA, CEMA and other industry standards.

7.4 Harmonic withstand design
Description on harmonic withstand design best practices and a brief discussion on the rating of capacitors and capacitor banks for future harmonic design considerations.

7.5 Harmonic amplification
Discussion on the impacts and consequences of harmonic amplification due to the de-tuning of harmonic filter banks and/or the application of multiple low-voltage capacitor banks.

7.6 Interaction with VFDs
A brief discussion on the evolution of variable-frequency drives (VFD) and the application and interaction of low-voltage capacitor banks with VFDs.

7.7 Special applications
A discussion on special application, e.g. ultra-capacitors, surge limiting capacitors, etc.

Section 8: Protection and Safety Requirements

8.1 Classifications: line, load, product personnel
Discussion of classification of protection requirements into one of four categories: line protection, load protection, product protection and personnel protection.

8.2 Pressure relief mechanisms
Detail discussion on pressure relief mechanism as applicable to individual low-voltage capacitor units pertaining to over-pressure conditions and fusing protection.

8.3 Surge suppression
Description of surge suppression techniques applicable to low voltage power capacitors to adhere to voltage withstand requirements and protection of capacitor banks from transients.

8.4 Arc-flash mitigation
Discussion of enclosure and facility arc-flash mitigation techniques and description of the application and operation of relays and fiber-optic sensors.

8.5 Fire mitigation
A brief description of enclosure and facility fire mitigation techniques in accordance with NFPA 70.

8.6 Heat dissipation
A brief description of heat dissipation techniques: convection cooling or forced-air cooling requirements.

8.7 Grounding
Description of grounding techniques and requirements for enclosures and facilities to ensure proper operation of low-voltage capacitors.

8.8 Special testing requirements for capacitor bank assemblies
A discussion on non-standardized testing requirements for capacitor bank assemblies including:

a. Hi-pot testing
b. Megger or insulation resistance testing

Explanation: A summary explaining the rationale behind the proposed requirements

The structure of the proposed outline is based on the following rationale:

1. ANSI/NEMA CP-1 2000 and IEEE Std. 18-2012 are standards familiar to many users. The proposed outline was chosen to be similar such that users of the new standard can quickly identify relevant sections and data based on their needs. This would add convenience and trust to the new standard.
2. The new standard should closely resemble the latest formats and style guides that are being used for ANSI/NEMA CP-1 2000 and IEEE Std. 18-2012. Users familiar with these standards would have greater ease in adoption and application of the new standard.
3. Chronology is important in a standard. New users should have a good understanding of design and construction aspects of capacitor units before evaluating rating, performance,

and testing criteria. With a good understanding of the fundamentals of Sections 4, 5 and 6, users are primed for application guidelines and protection requirements.

4. The structure of the outline is intended to make the standard easier to revise and adopt, should NEMA choose to propose it as a draft to standards organizations such as IEEE.

The categories of the proposed outline are based on the following rationale:

1. Sections 1, 2 and 3 are typical of most ANSI/NEMA/IEEE standards and guides. It is our intent to follow the same format.
2. Sections 4, 5 and 6 represent fundamental concepts that are critical to a good understanding of low-voltage capacitors. These section categories represent the building blocks to allow users of low-voltage capacitors greater understanding and evaluation of the operation, capabilities, and quality of the product purchased.
3. Section 7 contains critical application information regarding low-voltage power capacitors. This section would provide design application guidelines and requirements, including calculations, and specific examples. These applications represent the most common of low-voltage power capacitors today.
4. Section 8 provides users information on protection and safety requirements, which are typically related to the application, integration, and installation of systems, rather than individual capacitor units. It merits discussion in a new standard but is not fundamental information about low-voltage capacitor units.