National Electrical Manufacturers Association
Capacitors Section

Scope and High-Level Outline of a DC Capacitor Standard

Content

1. Scope

This standard applies to conventional DC capacitors (film foil oil) for HVDC - DC filter applications. This Standard will also be applicable to other applications where the capacitor unit(s) or bank(s) are exposed to a substantial direct voltage such as for example Neutral bus capacitors.

2. Normative references

IEEE Std 18 IEEE Standard for Shunt Power Capacitors
IEC 60871-1 Shunt capacitors for A.C. power systems having a rated voltage above 1000V

3. Definitions

Comments:
Definitions as per IEEE Std.18, Clause 3 are applicable with the following addition:

Grading resistors
Internally or externally mounted resistors connected in parallel with capacitor elements or capacitor units with the purpose to ascertain proper distribution of the DC voltage across the units and elements.

4. Design Requirements

4.1 Bank Ratings

4.1.1 Rated capacitance

Comments:
Permissible manufacturing tolerances and capacitance variations vs. temperature should be specified

4.1.2 Rated voltage HV DC filter capacitors

Comments:
The rated voltage shall be defined taking into consideration the maximum continuous DC voltage and the maximum harmonic voltages

4.1.3 Rated voltage Neutral bus capacitors

Comments:
The rated voltage shall be defined taking into consideration the maximum continuous DC voltage, the maximum harmonic currents and the highest transient voltages across capacitor

4.1.4 Rated current

Comments:
The rated current shall be defined in a suitable way taking into consideration the maximum continuous DC current and the maximum harmonic currents

4.1.5 Rated output

Comments:
Separate DC and AC output ratings of the bank can be calculated from the voltage and current rating values

4.1.6 Dimensions

Comments:
Requirements of bank-, rack- and unit dimensions and mounting details shall be specified

4.1.7 Audible Noise

Comments:
If relevant, the audible noise requirements on the capacitor banks shall be specified

4.1.8 Mechanical Design

Comments:
The requirements on the capacitor banks' mechanical design shall be specified

4.1.9 Grading Resistors

Comments:
The standard shall specify design criteria and requirements of the grading resistors.

4.1.10 Capacitor bank fusing and unit arrangement

Comments:
Internally fused capacitor banks: unit- and bank arrangement according to IEC 60871-1 Annex E section E2 is applicable
Fuseless capacitor banks: unit- and bank arrangement according to IEC 60871-1 Annex E section E4 is applicable
Externally fused capacitor banks: Not recommended for DC filter applications.

4.1.11 Insulators

Comments:
The electrical and mechanical requirements on the bank insulators and unit bushings shall be specified

4.1.12 Capacitor Bank Terminals

Comments:
The requirements on the capacitor banks terminals shall be specified

4.1.13 Seismic Requirements

Comments:
The seismic requirements on the capacitor banks shall be specified

4.1.14 Surface Treatment

Comments:
The surface treatment requirements on the capacitor banks, racks and units shall be specified

4.1.15 Welding Requirements

Comments:
The welding requirements on the capacitor banks, racks and units shall be specified

4.1.16 Capacitor Bank Nameplates

Comments:
As for AC capacitors, see IEEE 18, clause 6.8, the requirements on the capacitor bank nameplates shall be specified

4.1.17 Capacitor Unit Nameplates

Comments:

As for AC capacitors, see IEEE 18, clause 6.8.1, the requirements on the capacitor unit nameplates shall be specified.

5. Protection guidelines

5.1 General

Comments:
The protection of capacitor banks can be divided into Internal Protection and External Protection
Internal Protection: Clearing of faulty elements combined with element failure detection
External Protection: Preventing capacitor failures due to steady-state or transient overload, short-circuits, lightning strikes.

5.2 Internal protection

5.2.1 Internal fuses

Comments:
For capacitors with internal fuses, the fuses are the primary protection of DC capacitor banks. In case of a failure of a capacitor element, the fuse shall instantly disconnect the faulty element. The standard shall describe the consequences of disconnection of one or several elements and provide methods and criteria for detection and replacement of faulty units.

5.2.2 Fuseless design

Comments:
In case of fuseless capacitor banks an element failure shall result in a solid short-circuit of the faulty element. The standard shall describe the consequences of short-circuits of one or several elements and provide methods and criteria for detection and replacement of faulty units.

5.2.3 External fuses

Comments:
External fuses are generally not recommended for DC capacitors

5.2.4 Detection of element failures.

Comments:
In case the number of faulty elements will exceed acceptable limit, the faulty units shall be identified and replaced. The standard shall specify the method of detection of element failures.

5.3 External protection

Comments:
The external protection may consist of overload protection, short-circuit protection, earth-fault protection, differential protection and surge arrestors.

5.3.1 Capacitor overload protection

Comments:
The purpose of the overload protection is to prevent overloading of the capacitor due to DC or AC overvoltage. The standard shall provide recommendations of protection arrangement and suitable relay characteristics.

5.3.2 Short-circuit, earth-fault protection, differential protection

Comments:

The purpose of the protection is to detect phase - ground failures as well as rack-rack and rack-ground short-circuits. The standard shall provide recommendations of protection arrangement and suitable relay characteristics.

5.3.3 Surge arresters

Comments:
The purpose of the surge arresters is to ascertain that the switching- and lightning overvoltages will not exceed the insolation level of the capacitor bank. The standard shall specify recommended protection levels and arrester's energy withstand capability.

6. Testing Requirements

6.1 Routine tests

6.1.1 Capacitance measurement

Comments:
The Supplier shall specify acceptable tolerances in order to meet the specified bank tolerance at specified dielectric temperatures.

6.1.2 Loss determination test

Comments:
As in AC capacitors standard, see IEEE 18, clause 7.2.5

6.1.3 Short time overvoltage test

Comments:
As in AC capacitors standard DC voltage test, see IEEE 18, clause 7.2.1.1 a), but a test voltage level suitable for DC capacitors shall be specified

6.1.4 AC voltage test between terminal and container

Comments:
As in AC capacitors standard, see IEEE 18, clause 7.2.1.2

6.1.5 Grading resistor test

Comments:
As in AC capacitors standard, see IEEE 18, clause 7.2.4, but a suitable value of the test voltage has to be chosen to ensure the proper DC voltage distribution.

6.1.6 Sealing test

Comments:
As in AC capacitors standard, see IEEE 18, clause 7.2.3

6.1.7 Discharge test

Comments:
As in AC capacitors standard, see IEEE 18, clause 7.2.4
A suitable voltage level shall be chosen.

6.2 Type tests

6.2.1 Thermal stability test

Comments: A suitable test should be defined that will test the thermal capacity of the design taking into consideration both the DC current and the harmonic currents defined for the capacitor bank

6.2.2 AC Voltage Test between Terminals and Container

Comments:
As in AC capacitors standard, see IEEE 18, clause 7.1.2, but the appropriate level should be chosen from the transient rating of the capacitor bank

6.2.3 Lightning Impulse Test between Terminals and Container

Comments:
As in AC capacitors standard, see IEEE 18, clause 7.1.1, but the appropriate level should be chosen from the transient rating of the capacitor bank

6.2.4 Short-Circuit Discharge Test

Comments:
As in AC capacitors standard, see IEEE 18, clause 7.1.5, but a suitable level shall be chosen

6.2.5 Fuse disconnect test for internally fused capacitors

Comments:
As in AC capacitor standard, see IEEE 18, clause 7.1.7 but suitable test voltage levels shall be specified.

6.2.6 Measurement of the capacitance dependence on frequency and temperature

Comments:
A suitable test should be defined to verify the maximum capacitance variations

6.3 Verifications

6.3.1 Sound power level

Comments:
The audible noise requirements shall be verified

6.3.2 Mechanical design

Comments:
The mechanical strength of the capacitor bank shall be verified

6.3.3 External Corona

Comments:
The requirements regarding freedom from external corona shall be verified

6.4 Site tests

Capacitance measuring
Comments:
The measuring of each capacitor unit shall be provided as a base for the future maintenance

7. Quality Requirements

7.1.1 Quality assurance policy

Comments:
The required Quality assurance Standards shall be specified

7.1.2 Sub suppliers

Comments:
Approval criteria of sub suppliers with respect to local and federal regulations shall be specified

7.1.3 Tests of incoming materials

Comments:
The standard should specify incoming tests and controls of the various materials and components

7.1.4 Production tests

Comments:
The standard should specify tests that shall be performed during the various stages of the manufacturing process.

7.1.5 Packing and delivery

Comments:
The standard shall specify adequate packings with respect to the product's sensitivity and transportation method.

7.1.6 Quality audits

Comments:
Rules for quality audits and witnessed inspections and tests shall be specified.

8. Safety Requirements

8.1.1 Discharge devices

Comments:
After disconnection of the capacitor bank, the bank and each capacitor unit should be discharged. The standard should specify type of discharge devices, discharge time and residual voltage, time delay between disconnection and re-energization.

8.1.2 Grounding

Comments:
Before any maintenance work, the capacitor bank should be disconnected, discharged and solidly grounded. The standard should recommend procedures and type of the grounding devices.

8.1.3 Measures for preventing case ruptures and fire hazards

Comments:
The DC capacitors subjected to this standard are impregnated with flammable liquid which when exposed to high energy constitutes a potential fire hazard. The standard should specify criteria to minimize the fire hazard such as: ignition characteristics of the fluid, limitation of discharge energy, energy withstand of capacitor units.

9. Performance Requirements

9.1.1 Manufacturing tolerances

Comments:
The requirements on the manufacturing tolerances of the capacitor banks and units shall be specified

9.1.2 Capacitance variations vs. temperature

Comments:
The requirements on the capacitance variations versus temperature of the capacitor units shall be specified

9.1.3 Capacitance deviation due to element failures

Comments:
The requirements on the capacitance deviation due to element failures of the capacitor banks and units shall be specified

9.1.4 Internal inductance

Comments:
The requirements on internal inductance of the capacitor units shall be specified

9.1.5 Overload- and transient withstand capability

Comments:
The requirements on the overload- and transient withstand capability of the capacitor banks and units shall be specified

9.1.6 Failure statistics

Comments:
Maximum failure rate or MTBF (Mean Time Between Failures) shall be specified

9.1.7 Life expectancy

Comments:
The general life expectancy of the capacitor banks shall be defined and specified