
 TECHNICAL NOTE

Analysis of IEEE capacitor switching standards

Analysis of the IEEE standards in regards to the capacitive switch ratings of Classes CO, C1 and C2 to the former classification of "general purpose" and "definite purpose" capacitive switch ratings.

Many questions have arisen over the confusion of whether or not a "definite purpose" breaker is of class CO, C1 or C2.

Previously medium voltage circuit breakers were given a capacitive switch rating of "general purpose" or "definite purpose", in recent years thru the modernization and harmonization of IEEE and IEC standards the capacitive switch requirements have evolved into a more rigorous requirement for demonstrating the capacitive current switching ability of circuit breakers. IEEE C37 .09-1999 section 4.10 outlines the test procedure for labeling a high voltage circuit breaker with a capacitive switch rating of "general purpose" or "definite purpose". Table 1 is a summary of the tests that are required for capacitive switching according to this standard.

Table 1

Number of operations	Operation performed	C37.09-1999 4.10 Capacitor switching current tests
24	Open	1A isolated capacitor bank or cable switching @ 30% of rated cap switching
24	Close-open	1B isolated capacitor bank or cable switching @ 100% of rated cap switching
24	Open	2A back-to-back capacitor bank or cable switching @ 30% of rated cap switching
24	Close-open	2B back-to-back capacitor bank or cable switching @ 100% of rated cap switching
Total 96		

In order to achieve a "general purpose" rating there shall be no multiple restrikes during testing. For a rating of "definite purpose" there shall be no more than one restrike per operation and that restrike shall not be preceded by a current pause in excess of 1/3 of a cycle. All breakers tested for capacitive switching up to 2005 were subjected to the "general purpose" and "definite purpose" capacitive switch testing outlined in C37 .09-1999 until expansion of the capacitive switch ratings in IEEE C37 .09a-2005 with the classes of CO, C1 and C2. The restrike performance of the classes is as follows:

- C2: Very low probability of restrike during capacitance current breaking
- C1: Low probability of restrike during capacitance current breaking.
- CO: Unspecified probability of restrike during capacitance current breaking, allows up to one restrike per operation.

Further explanation of these capacitive switching classes in reference to the old labeling of general/definite purpose is made in IEEE C37 .06-2009 section 5.2 which states:

- For class CO (general-purpose) circuit breakers, no ratings for back-to-back capacitor switching applications are established. The capacitor bank or cable shall be "isolated" as defined in IEEE C37 .04a-2003, 5.11.
- For circuit breakers identified as a Class C1 or C2 (formerly referred to as definite purpose), Tests to prove Class C2 have to be performed according to the requirements of Table 2 of IEEE C37.09a-2005. Tests to prove Class C1 have to be performed according to the requirements of Table 2A of IEEE C37.09a-2005.

All breakers with a capacitive switch rating of general-purpose will become class CO while a "definite purpose" breaker can be either of the class CO, C1 or C2. Table 2 summarizes the testing requirements from IEEE C37.09a-2005 for capacitive switching classes C2 and C1 respectively.

Table 2

4.10.9.1.4 Three-phase capacitor bank current switching tests for Class C2			4.10.9.2.2 Three-phase capacitance current switching tests for Class C1		
Number of operations	Operation performed	4.10.9.1.4.1 Test-duty BC1 and 4.10.9.1.4.2 Test-duty BC2	Number of operations	Operation performed	4.10.9.2.2.1 Test-duty CS1 and 4.10.9.2.2.2 Test-duty CS2
4	Open	distributed on one polarity (step: 15°)	6	Open	distributed on one polarity (step: 30°)
6	Open	at minimum arcing time on one polarity	3	Open	at minimum arcing time on one polarity
4	Open	distributed on the other polarity (step: 15°)	3	Open	at minimum arcing time on the other polarity
6	Open	at minimum arcing time on the other polarity	6	Open	at minimum arcing time on the other polarity
4	Open	Additional tests to achieve 24 O distributed (step: 15°)	6	Open	Additional tests to achieve 24 O distributed (step: 15°)
4	Close-open	distributed on one polarity (step: 15°)	6	Close-open	distributed on one polarity (step: 30°)
32	Close-open	at minimum arcing time on one polarity	3	Close-open	at minimum arcing time on one polarity
4	Close-open	distributed on the other polarity (step: 15°)	3	Close-open	at minimum arcing time on the other polarity
32	Close-open	at minimum arcing time on the other polarity	6	Close-open	at minimum arcing time on the other polarity
8	Close-open	Additional tests to achieve 80CO distributed (step: 15°)	8	Close-open	Additional tests to achieve 80CO distributed (step: 30°)
Total 104			Total 48		

It is important to note that for class C2 testing the breaker first must be subjected to test duty 3 (TD3) which consists of three operations at 60% of the rated breaking capacity. This is performed as a preconditioning test. For class C1 testing this is not required. The breaker will have passed C2 if no restrikes occurred during the testing. Should a restrike occur, the testing must be repeated. For C1 testing the breaker must experience no more than one restrike. Should multiply restrikes occur testing must be repeated. Class CO may be demonstrated by completing either the C1 test program or C2 test program allowing up to one restrike per operation.

Comparing the tables of testing requirements from C37.09-1999 and C37.09a-2005 combined with the passing requirements, a breaker which once was listed as "definite purpose" could have any of the following listings under the new standard: (CO, C1 or C2).

1. CO if the breaker passed with "one restrike per operation".
2. C1 if the breaker passed with one restrike during test 2A and 2B
3. C1 if the breaker passed with no restrikes during test 1 A, 1 B, 2A and 2B.
(possible C2 breaker)
4. C2 undetermined, not enough tests were required under the old standard (96 vs 104)

An example of this would be the ADVAC model 3 15 kV 2000 A 50 kA breaker which was tested to the C37.09-1999 standard. The report from that test (CESI GPS-AS/014803) shows that the breaker passed all test with no restrikes. This means that the breaker passed beyond the C1 requirements but is still short of a C2 rating. Retesting would be required for C2.



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