Recent Changes to the IEEE High-Voltage Circuit Breaker Rating Standard, Part 2

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This is the second of a two-part Technical Brief that describes the changes made to the 2018 Edition of IEEE C37.04, IEEE Standard for Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V. Part 1 of this Technical Brief covers the introduction of the revision through the close and latch rating. This part picks up where Part 1 left off with the service capability duty requirement.

The service capability duty requirement has been completely revised from the previous edition. For circuit breakers rated less than 72kV it has become much more severe. Service capability is defined as the minimum allowable amount of current that must be interrupted prior to allowing maintenance or servicing of interrupter parts or assemblies and is considered a measure of reliability and a guide to maintenance.

For some historical perspective, the 1979 version of C37.04 required that a circuit breaker rated below 121kV perform 400%, or four times the rated short circuit current, accumulated duty. At that point parts could be replaced. Air-magnetic and oil circuit breakers typically employed "arcing tips" which carried most if not all of the arcing current during interruptions. This helped protect and preserve the main current carrying contacts so that continuous current carrying was not negatively impacted after many interruptions. During servicing of these types of circuit breakers, the arcing tips could be replaced or "dressed" to restore as-new condition and the main contacts were visually inspected for any signs of arcing and maintained only as required.

During the late 1970's and early 1980's the use of sealed interrupters, such as vacuum and SF_6, became much more prevalent at medium voltage. Since most of these are "sealed for life", inspection and servicing the contacts became impossible without replacing the entire interrupting unit. Because these types of interrupters could not be inspected and serviced, C37.04g was approved in 1986 to increase the accumulated duty requirement from 400% to 800% for these types of interrupters.

When the next revision was released in 1999, it unfortunately had a number of conflicting requirements. With respect to accumulated duty, there was agreement between test engineers and third party certifiers that there was no intent in the 1999 version to increase the requirement to anything above the existing 800%. This was met by the summation of *any* current values interrupted that were higher than the continuous current rating, up to the full short-circuit rating of the circuit breaker.

The "fix" introduced by the 2018 revision was to change the capability to simply 8 times the rated short-circuit breaking current (I_{sc}) for circuit breakers rated below 72.5 kV and 6 times I_{sc} for circuit breakers rated 72.5 kV and above. But, the "fix" also disallows using any current switched that is less than 60% of the rated short-circuit current for the summation. Tests performed at 60% up to less than I_{sc} are only accumulated into the total by multiplying the current switched by a factor of 0.4. This, and a change to the required arcing times found in C37.09-2018 which is outside the scope of this paper, has had the effect of arguably increasing the costs of testing and qualifying circuit breakers. Given the extremely high field reliability of circuit breakers tested the "old way", in some cases using exactly the same interrupters, it could be argued that the new procedure adds no appreciable benefit to the user.

In the spirit of harmonization with the IEC, electrical endurance Class E1 and E2 have been introduced in this revision. Class E1 is met by passing all of the required short circuit tests, including the service capability duty requirement. The extended electrical endurance Class E2 can be met by first meeting the requirements for Class E1. Then, without performing any maintenance to the tested breaker, subsequently continuing the tests by subjecting

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the circuit breaker to an E2 test sequence by performing additional tests. These consist of 15 additional symmetrical opening operations and 14 additional duty cycles at 60% I_{sc} plus one additional symmetrical duty cycle test at 100% I_{sc}. For the time being, all Powell circuit breakers will be classified as E1. The "problem" with attaining the additional rating is very significant cost. A complete short-circuit interrupting retest would be required on each rating that utilizes a different family of vacuum interrupter in order to attain an E2 rating. An E2 rating cannot be gained by simply performing additional tests on the existing qualified circuit breakers.

C37.04a – 2003 Amendment 1: Capacitance Current Switching, was also incorporated into this revision almost in its entirety. Due to IEEE C37.100.2-2018 - IEEE Standard for Common Requirements for Testing of AC Capacitive Current Switching Devices over 1000 V being approved and published, some terms have changed and the ratings have been expanded. What was termed rated back-to-back capacitor bank breaking current (I_{bb}) in C37.04a is now called rated back-to-back capacitor bank transient peak inrush making current (I_{bb}). Also, rated back-to-back capacitor bank inrush making frequency (f_{bi}) in C37.04a is now called back-to-back capacitor bank inrush current making frequency (f_{bb}). The preferred back-to-back inrush current ratings and inrush current frequencies are unchanged from those published in C37.06 – 2000. However, two alternate ratings have been added in this revision. Alternate 1 ratings were added to accommodate some types and/or ratings of interrupting technologies in use today and are substantially lower than the preferred ratings. Alternate 2 ratings were added to address some exceptional applications and values. It is worth noting that alternate 2 ratings can only be tested by synthetic methods which is only available in some laboratories worldwide. Another notable change is that capacitance switching Class C0, which has an unspecified probability of restrike during capacitive current breaking with up to one restrike per operation allowed has been added.

The term "interrupting time" has been was clarified by adding that it is based only on a three phase symmetrical short-circuit current. Longer interrupting times for other types of faults has been referred to C37.010

The operating endurance requirements have changed significantly. The terms Class M1 and Class M2 have been introduced, once again in the spirit of harmonizing with the IEC. However, there is a very distinct difference in the requirements of those ratings from the IEC. The Class M1 no-load mechanical operating endurance requirements are the same as the requirements from the previous version. Depending upon the ratings of the circuit breaker the requirements range from 10,000 to 2000 operations. Class M1 in the IEC is 2000 operations for all ratings and 10,000 for Class M2. Since the Class M1 ratings of 4.76 and 15kV, 1200 and 2000A, 20-31.5kA circuit breakers remain at 10,000 operations, Class M1 in C37.04 is equivalent to Class M2 in the IEC for the same ratings. All Again for the time being, all Powell circuit breakers will be classed as M1 for exactly the same reason as the Class E2 rating.

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