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TechTopics No. 97

Ratings for retrofitted switchgear

Users are actively pursuing ways to extend the life of existing equipment for various reasons, including avoidance of major replacement expense and lengthy downtime for replacement of complete lineups of switchgear. The most common form of life extension is referred to as a “retrofit”, and this may take a number of forms. When the first retrofits were done, over 20 years ago, the drawout circuit breaker was usually replaced with a circuit breaker using the same metal framework (the “truck”), with the internal elements of the circuit breaker replaced with a modern circuit breaker operator. In the typical application for an air-magnetic circuit breaker, the magnetic structure, arc chutes, main contacts, arcing contacts, operating mechanism, and controls were all removed and replaced.

Over time, the practice evolved, as the available supply of used circuit breakers available to begin the retrofit process decreased. Complete new replacement circuit breaker designs were created, which incorporate no parts from the existing circuit breaker, and which can be provided at reasonable cost.

Since modern circuit breakers are designed to meet the present day standards, the question of the ratings to be applied to the replacement circuit breaker (and hence, to the overall installation) becomes important.

The ratings of circuit breakers and switchgear have changed over time. Prior to 1964, the ratings for circuit breakers were based on total (asymmetrical) current. In 1964, the IEEE C37.04 standard was revised to the symmetrical basis of rating.

The 1964 revisions of the standards were based on the physics limitations of the technologies of the time, and this resulted in ratings that allowed for greater interrupting capacity (in kA) as the application voltage decreased, until a thermal limit was reached. This was embodied in the use of a voltage range factor (K), and rating of a circuit breaker at a particular interrupting current (I) at rated maximum voltage (V), while allowing for an increase in the interrupting current to an upper limit of KI at a minimum voltage, V/K. These circuit breakers are often termed as “K-factor circuit breakers”, or “constant-MVA circuit breakers”. For further discussion, see TechTopics No. 04, “kA rated circuit breakers and switchgear”.

In the late 1990’s, the basis of the standards changed again, to eliminate the K factor. The standard with the preferred ratings values, ANSI C37.06, anticipated this basic change in its 1997 edition, where the ratings values were changed to eliminate the K factor, by setting it equal to 1.0 for all circuit breakers. The basis of the change of ratings values in the other standards was not completed until the fundamental standard, IEEE C37.04, was revised in 1999. Subsequent to this revision of the standards, almost all modern circuit breakers are rated in terms of the interrupting current (in kA), which does not increase as voltage is reduced.

So, recognizing that modern circuit breakers are rated in kA with no K factor, what ratings apply to the retrofitted switchgear installation? This issue was addressed in the first edition of the retrofit standard, IEEE C37.59, “Requirements for Conversion of Power Switchgear Equipment”, which established the philosophy for retrofit ratings that continues today.

This philosophy is contained in section 5 of C37.59, which says "The ratings of all equipment were defined by the standards that were in effect at the time of its manufacture. Converted equipment shall continue to meet the original ratings unless otherwise agreed between the purchaser and the converter."

So, under C37.59, there are at least two possibilities for ratings of converted (retrofitted) equipment. Either the ratings match those of the original installation (the basic philosophy of C37.59), or the ratings of the original installation are increased.

Option 1: Match replacement circuit breaker ratings to existing circuit breaker ratings:
C37.59 requires design verification to support the capabilities of the retrofitted switchgear. This requires a thorough analysis of the retrofit design in the existing switchgear structure to demonstrate that the ratings of the retrofitted equipment at least match those of the existing installation. The manufacturer must review all of the performance requirements of the existing equipment and verify either by test or by evaluation of previous tests that the ratings of the existing equipment will not be reduced by the retrofit process. So, the basis for the verification process is the version of the standards to which the existing equipment was designed and manufactured.

If the original equipment was rated for circuit breakers with a K factor greater than 1.0, then the retrofitted circuit breakers must be evaluated in the same manner. Let us consider a simple, and quite common, retrofit application, the replacement of an existing "250 MVA class" circuit breaker. These circuit breakers were rated for a maximum voltage (V) of 4.76 kV, with interrupting current (I) of 29 kA at 4.76 kV, with voltage range factor (K) of 1.24, and maximum interrupting current of 29 x 1.24 = 36 kA at V/K = 4.76 / 1.24 = 3.85 kV. Thus, the circuit breakers were capable of a short-time current of 36 kA, and this capability (and the other ratings) must be maintained after the retrofit process is completed. The retrofit firm must consider this in the design verification process.

If the existing ratings are maintained with no change, the time to accomplish the retrofit installation is reduced (normally) to the time that it takes to remove and install the circuit breaker element and to validate interlock functionality. Thus, the downtime and associated cost involved in the retrofit installation on the circuit is relatively minor.

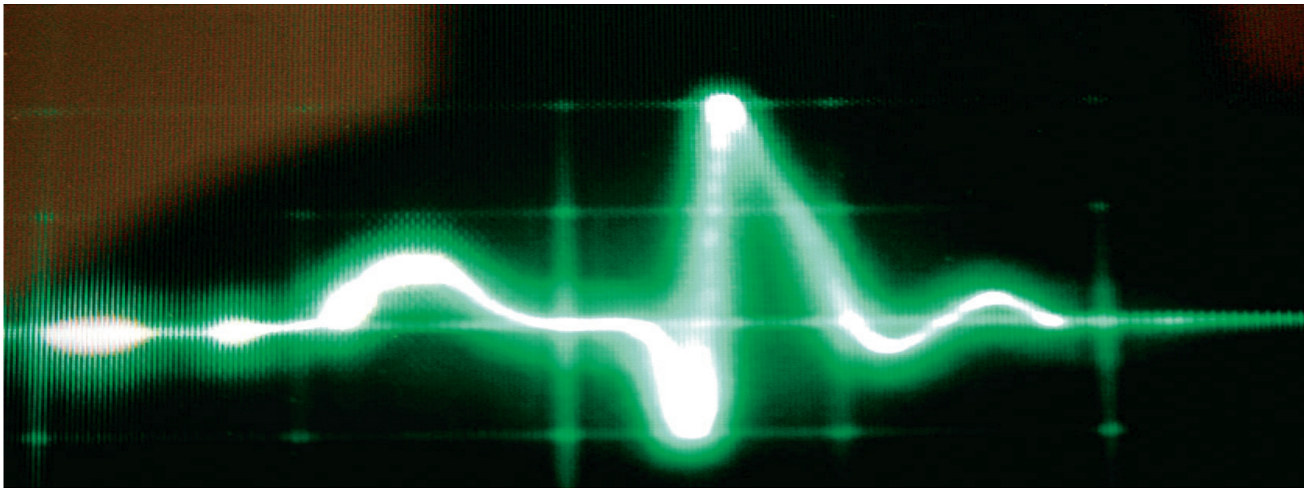
Option 2: Increase ratings from the existing ratings to some higher ratings:
A retrofit application to achieve higher ratings is more complex, as the retrofit firm must evaluate the entire switchgear assembly, not just the switchgear cell for the circuit breaker that is being replaced. System maximum short-circuit currents often increase (especially with increase in local generation), and can exceed the short-circuit ratings of the existing switchgear and circuit breakers. Such increased system requirements demand that the capabilities of the existing equipment be evaluated and addressed.

One common retrofit of this type is to match the modern kA ratings, e.g., increasing from the historic 250 MVA class switchgear (maximum 36 kA short-time current) to the modern 40 kA rating. A second common type of retrofit is to increase the short-circuit ratings to a higher class, e.g., from the historic 250 MVA class to the historic 350 MVA class, or even farther to the modern 50 kA rating. When increasing ratings, the retrofit firm must extend the design verification process to consider the existing switchgear cubicles as well as the new replacement circuit breakers.

If it were desired to increase our example 250 MVA class switchgear to the modern 40 kA rating, the design verification process would have to demonstrate that the structures could withstand the 40 kA short-time current (increased from 36 kA) and also the mechanical forces from an increased peak current of 104 kA (increased from 97 kA). Experience indicates that this may often be possible without modification of the bus structure or bus supports in the existing equipment.

However, consider the case of a retrofit to increase from the 250 MVA class to the 350 MVA class or even the modern 50 kA rating. This would involve increasing the short-time current rating from 36 kA to 49 kA (for 350 MVA class) or 50 kA (for the 50 kA rating), and of more importance, to increase the peak current withstand from 97 kA to 132 kA (for 350 MVA class) or 130 kA (for the 50 kA rating). This will almost always require increasing the level of support of conductors (often called "bus bracing") in the switchgear structures.

So, if an increase of ratings is required, the user faces the higher cost associated with the replacement circuit breakers, the costs associated with modifications of bus structures in the existing equipment, and the cost associated with design tests to demonstrate the increased ratings of the switchgear bus system. Depending on the bus system upgrade requirements, there can be increased downtime for the complete installation if the bus structure must be modified.



It is our practice to offer retrofits on the basis of option 1, match existing ratings, unless the user requests increased ratings on the basis of option 2. Of course, users may choose to upgrade both the switchgear and the circuit breakers to meet increased short-circuit system requirements, or to upgrade either the switchgear or the circuit breakers to prepare for future expected increases in available short-circuit current. The decision on how extensive a retrofit upgrade should be is a complex issue, and must be addressed on a case-by-case basis.

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