Low- and very low- frequency short-circuit current interruption with vacuum

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ABSTRACT

The main application for vacuum interrupters (VI) is in electrical power systems at frequencies of $f_r = 50/60\ Hz$. Other applications at different f_r include rail electrical power systems that run at $16-2/3\ Hz$ and $25\ Hz$. VI worked successfully in these applications for many years. Green energy applications such as wind turbines, pumped storage, DC to AC converters in solar parks and shipboard applications can generate temporary fault conditions with very low frequencies. Low frequency applications generate very long arcing times and high transferred charge, making current interruption at the current zero (CZ) difficult. This work calculates the interruption performance boundary to frequencies between $0.5-2\ Hz$ based on the test performed at $16-2/3\ Hz$ and $50\ Hz$. The contact erosion rates were also grouped into three different situations as a function of the current, and the erosion during multiple short-circuit operations from $10-40\ kA\ rms$ at $50\ Hz$ and at several hundred of amperes at $0.5-5\ Hz$. Test sequences from the generator circuit breaker standard are also examined, such as delayed CZ and very high direct current (DC) offset tests. These tests are effectively equivalent to lower frequency tests. Finally, experiments were performed at $2.4\ Hz$ at $1250-1500\ A\ rms$ to observe the impact of multiple switching operations on the contacts, metal vapor deposit on the ceramics, and heat build-up in VI. Three different contact systems and sizes were tested.

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