Design Of High Current HEMP Filters For Reliability

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***Abstract*— Most High Altitude Electromagnetic Pulse (HEMP) protection filters are used in critical infrastructure protection applications and therefore reliability is of paramount importance. This paper covers the key design factors affecting the reliability of these filters with a focus on high current ratings.**

Keywords-High Altitude Electromagnetic Pulse (HEMP); Nuclear Electromagnetic Pulse (NEMP); MIL-STD-188-125; reliability; filters;

I. INTRODUCTION

MIL-STD-188-125 is the standard normally used to define performance requirements of HEMP filters for critical infrastructure applications. This requires verification testing of HEMP filters when first installed. However, to ensure continued protection the HEMP filter must also perform without failure or degradation over its entire service lifetime. A good maintenance plan is important to identify any degradation of performance but is not a substitute for reliable filters.

II. KEY DESIGN FACTORS

Key factors affecting reliability of electrical devices derived from MIL-HDBK-217 include operating temperatures of components, and safety margins on voltage and current ratings. With regards to filters, these reliability factors impact on the choice of capacitor and inductor materials, their design and integration into the filter enclosure, and the choice of material for the filter enclosure.

A. Voltage Safety Margins

The voltage safety margin has a direct impact on the reliability of capacitors. A large ratio of capacitor test voltage to working voltage reduces electrical stress from voltage transients experienced by the filter over its service life. The use of self-healing capacitor technology further improves reliability allowing the capacitor to recover from minor overvoltage transients. Empirical measurements on filters in service demonstrate the benefit of this approach. Figure (1) shows the measured capacitor parameters of 42 filters after 20 years of continuous service utilising self-healing filter capacitors with a voltage safety margin of greater than 6:1. The plot shows little change in capacitance value after 20 years. There were also no electrical failures of any of the filters in service although some transient suppression varistors had been replaced.

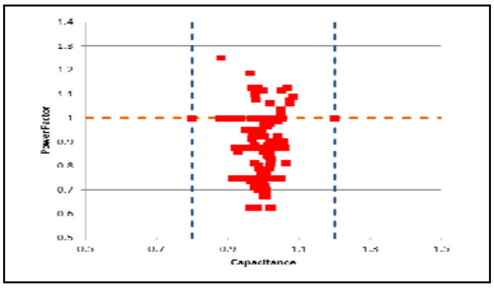

Figure 1. Normalised capacitance of filters after 20yrs of service

B. Temperature Rise

Higher temperatures have a negative impact on reliability therefore maintaining cool running of a filter is vital. There will inevitably be greater heat dissipation in high current filters and any shortfalls in the design or manufacture will have exacerbated consequences; one problematic area is enclosure design and material choice where there can be a conflict between shielding performance and eddy current heating effects.

Figure (2) shows the eddy current heating effect on three shielding barriers of different grades of steel with a 1200A conductor passing through. It follows that without careful material selection any filter enclosure could introduce serious eddy current heating to a filter, shortening its service life.

By taking this into account in the design of a 1200A filter, it was possible to reduce the overall case temperature rise above ambient, at full load current, from 30°C to 18°C; this translates to a calculated MTBF improvement from 256,000 hours to 406,000 hours. This will result in significantly improved reliability in service.

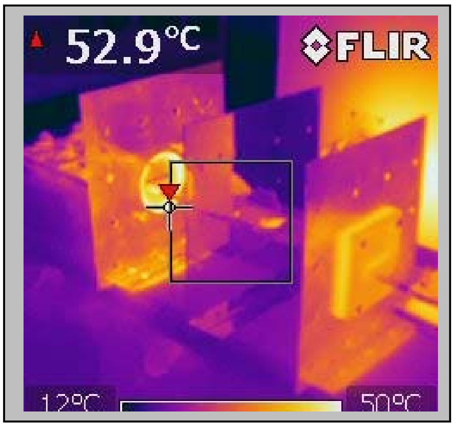

Figure 2. Eddy Current Heating in Steel Barriers