



HEMP FILTER MAINTENANCE AND MONITORING

Filter Maintenance

MPE power filters and EMP filters have been in service in strategic installations for at least 20- 30 years and have been demonstrated to be very reliable and not in need of any maintenance. Some filters have been removed after 20 years continuous service to upgrade to filters meeting the newer Mil-Std-188-125 specification, and when tested were found to still conform to their original electrical specification. MPE's latest HEMP power line filters use the same capacitor technology as proven in these filters and are designed and manufactured to the same design rules and manufacturing controls, so would be expected to exhibit similar levels of reliability.

Transient Suppressor Maintenance

Transient suppressors within HEMP filters are usually varistors and these must be considered as consumable devices which could potentially degrade with time.

Varistors would not be expected to be subjected to HEMP transients in normal use, but could experience transients due to local or distant lightning strikes, power switching transients, or other disturbances on the line. These transients are somewhat unpredictable and cannot be easily be designed for.

Data from varistor manufacturers indicates that varistors can be permanently degraded when the energy from such transients is sufficient to cause local overheating at the varistor grain boundaries beyond a certain temperature. If however, the energy of the transients is such that the heating effects do not cause the grain boundaries to exceed these threshold temperatures, and there is a recovery time before subsequent transients are encountered, then the varistor will recover without any degradation.

This means that the bigger the varistor used, the less likely it is to degrade, or the longer it is likely to survive without degradation.

MPE use 60mm disc varistors in its HEMP power line filters. These have been tested as being capable of surviving at least 250 Mil-Std-188-125 E2 pulses, so have a large safety margin for reliability. This type of varistor has been in service in MPE filters used in EMP protection systems for about 20 years without any reports of significant degradation.



Transient Suppressor Monitoring

Transient suppressor monitoring, although possibly desirable from a user's point of view is not as practical as it might appear for the following reasons

1. Transient suppressor degradation cannot be easily monitored.
2. As varistors degrade and approach failure they will conduct more leakage current which will show up as an increased temperature rise but this will not become significant until failure occurs due to thermal runaway.
3. This temperature can be monitored to record failure but cannot easily predict degradation
4. As part of their failure mode varistor resistance will decrease and increased leakage current will be conducted causing overheating.
5. This will ultimately cause thermal runaway and the varistor will overheat, and the excessive energy and overheating will cause the varistor housing to rupture, usually causing the varistor terminal soldered connections to melt and fuse itself, taking the varistor out of circuit.
6. In high current filters the line current causing the varistor to fail will be insufficient for the line fuse or circuit breaker to blow so the varistor could fail without the user being aware of it. However the likelihood of varistor failure is very low if high energy varistors are used.
7. Experience has shown that in every case we have seen, when such varistors have failed due to exceptional unexpected transients, the filter itself is always electrically undamaged.
8. One common method of varistor monitoring for varistors used on lower energy applications such as secondary lightning protection is to use three terminal varistors with a built in fuse. In this case if the varistor overheats, the fuse will melt isolating the varistor. This has the benefit of having a monitor signal to indicate the status of the varistor but has the following potential shortcomings in HEMP protection applications.
 - a. 3 terminal monitored varistors are only currently available in sizes up to about 30mm diameter (25kA max peak current) so will be much less reliable than the larger 60mm diameter varistors (70kA max peak current), and may not be sufficiently large to meet the Mil-Std-188-125 E2 pulse requirements.
 - b. The fuse within the varistor is in series with the varistor element so adds resistance and inductance into the varistor path so may reduce its current handling capability and/or its operating speed. This may adversely affect its residual current performance in high speed HEMP applications.
 - c. The monitor signal is in the unprotected "dirty" EMP area so the monitoring signal will also need filtering if monitored in the "clean" area. If a status lamp is fitted in the unprotected "dirty" area, the lamp itself will be unprotected from a HEMP event.
 - d. The monitor only provides an indication when the varistor has actually failed and protection has been lost, not degradation.

Therefore maintenance, coupled with high safety margin by using large transient suppressors, is the preferred approach for reliability and maintenance, and this has been adopted as the preferred approach for strategic installations in various countries.



MPE Filter Specification and Maintenance Recommendations

1. MPE recommends that varistor transient suppressors of at least 60mm diameter (70kA) rating are used for high reliability and minimum maintenance or replacement over extended periods. MPE installations using these varistors have been in service for more than 20 years with few reported problems
2. Varistor failure is evident visually as the varistor enclosure will usually have ruptured but filter terminal covers do need to be removed for inspection of varistors.
3. The best maintenance plan is to regularly monitor varistor degradation. Varistor degradation is easily measured by measurement of the varistor voltage at 1mA. This value is declared in the varistor manufacturer's specification and normally has a tolerance of $\pm 10\%$. As the varistor degrades, this value will reduce, and once it falls below 10% of its nominal value, the varistor is considered to be out of specification and should be replaced. This V at 1mA figure can easily be measured using a simple and cheap hand held tester such as the Bourns Surge Protector Test Set Model 4010-01. The only disadvantage with this test is that the power must be switched off and one terminal of the varistor must be disconnected to carry out the measurement.
4. MPE would recommend the following maintenance schedule for filters and transient suppressors (although this could be modified based on experience of site history after an initial period of monitoring)
 - a. Every 1-2 years, visually inspect filter cases for evidence of overheating, paint blistering, especially around areas where varistors are known to be positioned inside the enclosure
 - b. Every 3 years, or during planned shutdowns, or after a known unexpected transient event.
 - i. Remove input power filter lid to inspect for varistor failure. This would normally show up as ruptured varistor case, blackened varistor case, evidence of soot, etc. This may require power to be switched off to filter for safety reasons.
 - ii. Disconnect power, remove power filter input lid, disconnect live side of varistor from filter terminal and test varistor for V at 1mA using Bourns Surge Protector Test Set Model 4010-01 or similar. Check measured figure against manufacturer's data plus previously logged date for this installation.
 - iii. Log data for future reference. Replace varistor if out of specification or close to limit.
 - iv. Repeat measurements periodically but reassess periodicity based on assessment of previous results and degradation.
 - v. Ensure varistors are reconnected correctly, lids and gaskets are re-installed properly and are not damaged, and lids are re-torqued to correct levels.
 - c. Periods of checking are for guidance only, may be site specific depending on importance, availability of time to power down, and may be amended based on site experience.