Feed Thru Filters and Silver Migration

Surface migration of the plating metal on feed-thru bodies causing apparent low resistance to ground failiures has been long been noted. This is caused by both the presences of both a DC voltage and a water path from ground to the center pin. This article discusses the phenomenon of ion migration, what to look for, leakage characteristics of different materials, and how to design around the problem.

The Phenomenon:

A DC bias and water path from postive (+) to negative (-) is all that is required to form what in effect is a miniature plating bath. Dendrites or tendrils of metal ions grow across the glass/epoxy dividing the center pin and the outer body of the filter. Given enough water and voltage, a short condition is almost instantaneous. A thin coating of water is all it takes, but this is difficult to achieve since the sealing epoxy used in filters is by nature hydrophobic is possible under frost conditions. It may require multiple cyclings for a path to develop as the water is broken down by electrolysis during the migration process. The dendrites are susceptible to current burn-thrus but will repair themselves given DC voltage and more water. The most common occurrence of ion migration affecting a system is not in the field but during temperature cycling under power in the factory. Temperature extremes with significant ambient dwell times allow sufficient condensation to form. Once the water is consumed, the migration of ions will stop. However, any detected low resistance may or may not clear itself depending on the power fed through the circuit.

What to Look For:

Migration makes itself known as a low resistance failure of the bulkhead mounted filter. If the current is high enough, the migration tendril will burn through and the circuit will have seemed to repair itself. However, if mositure returns, the tendril will grow back and an intermittant short situation may be apparent. Migration looks like a grey film on the sealing glass or epoxy of the feed-thru. This migration is strictly a surface phenomenon, once removed by slight mechanical action; the filter will function as designed. In fact, many who come across this problem inadvertantly wipe the dendrites off when removing the part for further testing. Photo 1 illustrates the balling of water on sealing epoxy and photo 2 illustrates the dendritic growth after a DC voltage is applied.

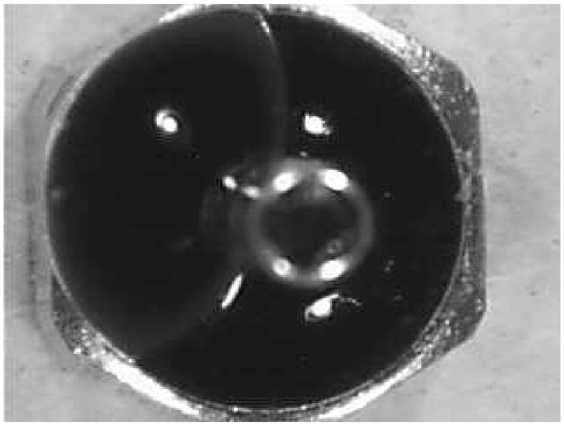


Photo 1

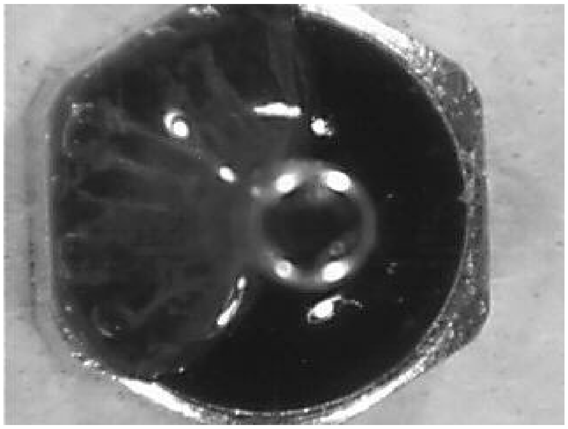
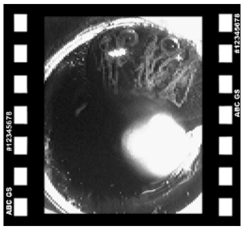
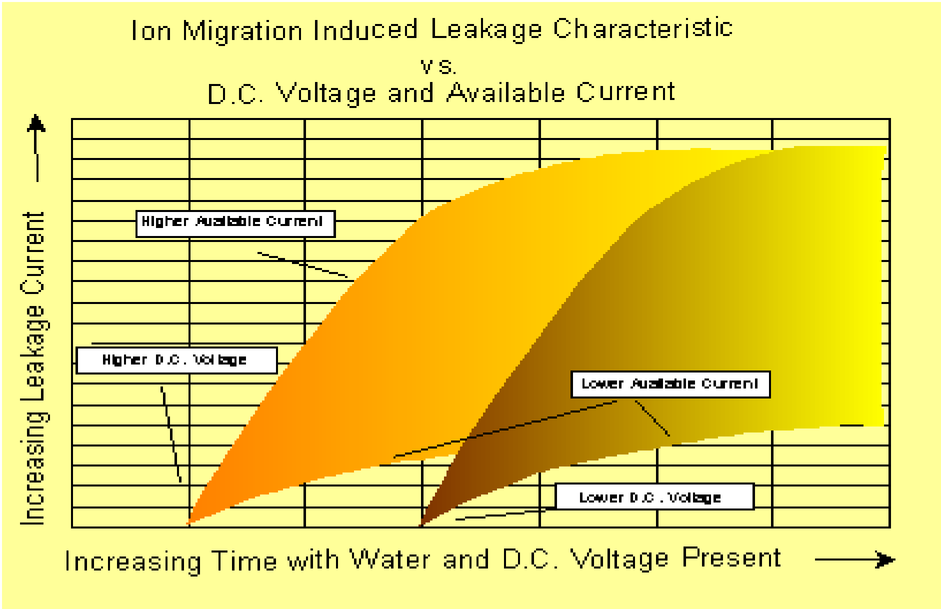


Photo 2

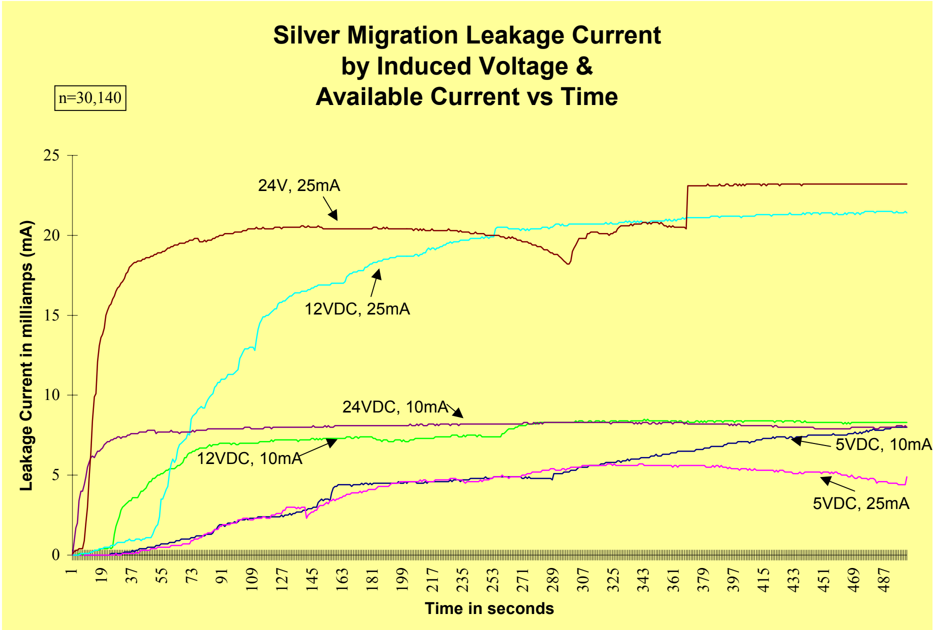
A Demonstration:



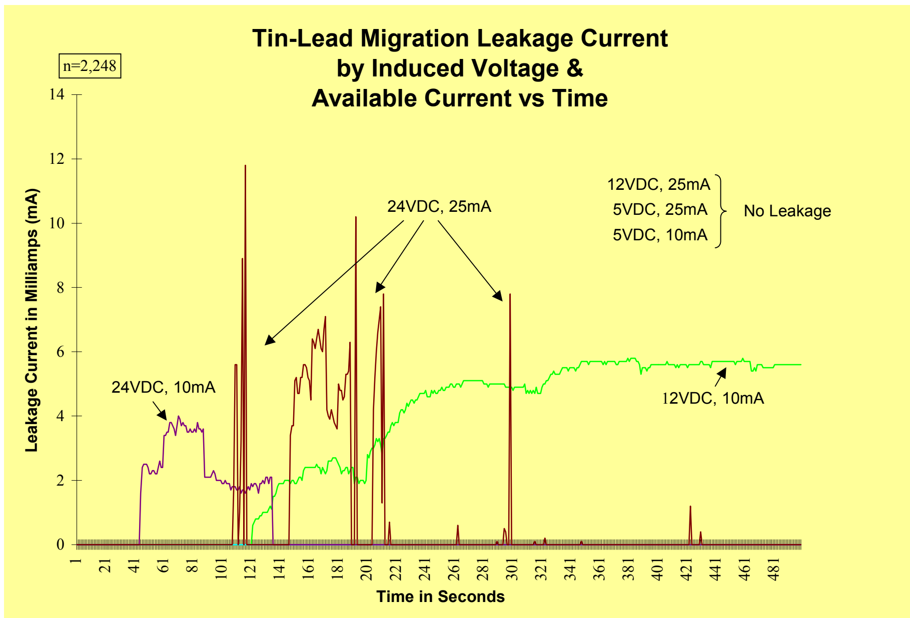
Visit our website to see a video of silver migration at http://www.emifiltercompany.com/migration1.001.wmv. In the video, a filter has a drop of deionzed water on the epoxy sealed face. A 24 VDC supply limited to 25 mA is used to drive the migration of the silver plating. As long as there is DC voltage and a continuous water path, *migration will occur*. The higher the DC voltage, the faster the migration and less time for measurable leakage. Graph 1 illustrates this general relationship between voltage and available current on leakage rates. Graphs 2 and 3 illustrate actual leakage examples of silver and 90tin/10lead plated filters respectively.



Graph 1



Graph 2



Graph 3

One can see that different materials migrate at different rates and exhibit different leakage characteristics. Silver migrates most easily of any of the commonly used plating materials used in bulkhead-mounted feed-thrus and filters. 90tin/10lead exhibits better resistance to migration. Notice how the current leakage related to silver is continuous once a path has been established, while the 90tin/10lead shows only intermittant leakage. This is due to the higher electrical resistance of the 90tin/10lead, which causes the bridge to burn open when there is sufficient power. Silver will readilly migrate with any voltage while the 90tin/10lead require about

12VDC or higher *and* less than 25mA to sustain a leakage path. The best material for resisting migration is gold. Table 1 illustrates the time required to for migration to manifest itself as a .1mA leak.

Table 1: Time in Seconds for .1mA Leak

VDC →	**5vdc**		**12vdc**		**24vdc**	
Current ->	10 mA	25mA	10mA	25mA	10mA	25mA
Silver	24	27	5	6	1	1
90Tin/10Lead	600+ *	600+ *	122	600+	45**	109**
Gold	600+ ***	600+ ***	600+ ***	600+ ***	600+ ***	600+ ***
* Beginning of migration optically observed ** Intermittant leak ***No observed reaction						

What to Do:

There are several options in dealing with migration. The first is to merely brush the migrated material off the surface of the filter. In no way is the filter harmed. Some of the plating may be tarnished, but it is only a cosmetic effect. Coating the filter after installation with a lacquer is an easy way to keep water away from the plated material. Do not bury the epxosed portion of the filter with epoxy as the volumetric change of thick epoxy during curing can litterally pull the center pin loose from the filter or feed-thru. The most foolproof option is to use filters with tin-lead or gold plating. 90 tin/10 lead compositons offer good migration resistance at or below 12 VDC at a very economical price. At 24 VDC and above, migration does occur but it is usually self-clearing. With RoHS becoming a large consideration, the ultimate choice is gold. In our trials, we have been unable to get gold to migrate under any realistic condition. Specifying the gold thickness 30 to 60 micro inches is sufficient to stop migration and not risk gold embrittlement.