# ELECTROLYTIC CAPACITOR FAILURE MODES IN TEKTRONIX TM SERIES POWER MAIN FRAMES.

# SELF CRACKING RESISTORS IN A TELEQUIPMENT D52 OSCILLOSCOPE.

**H. Holden, Oct 2014.**

## Electrolytic capacitor failure modes:

It is common knowledge that electrolytic capacitors dry up, ultimately out-gas and fail. It is usually this component which sets the lifetime limit of most electronic devices these days and it is the ultimate tool for “life cycling” appliances.

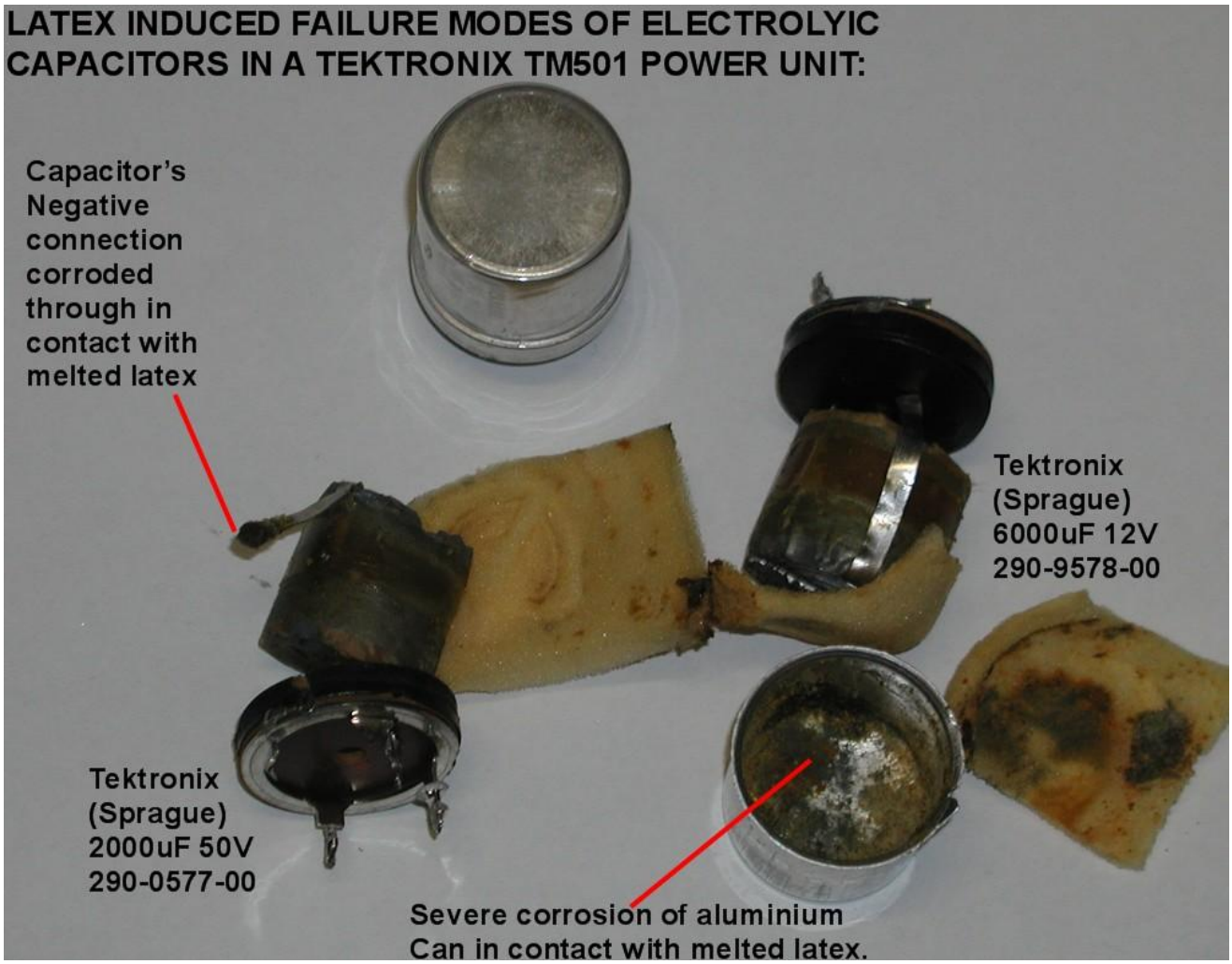
Electrolytic capacitors carelessly placed near heat-sinks have a shorter life and many times the life of an 85 Degree C rated electrolytic can be less than 1000hrs continuous use. Typically power supply electrolytics fail first as they are located in hotter areas and have high ripple currents. Good quality high temperature electrolytics with 105 DegC ratings can exceed 4000hrs use. Special quality electrolytics, for example those made by Rifa, have 125 DegC ratings and are suited to automotive applications where the environment is more hostile.

Often though, depending on the value of the appliance, it can be worthwhile replacing the electrolytics to get more life out of the appliance. I have kept many computers & monitors working for years well past their common expiry dates by replacing power supply electrolytic capacitors.

There are other mechanisms of electrolytic capacitor failure:

The faulty electrolytic capacitors reported here are interesting because they had not dried out but simply had gone open circuit. They were the two 2000uF 50V DC rated capacitors in a Tektronix TM501 power module. This particular module, manufactured in the late 1970’s, looked brand new without a mark on it and had clearly seen very little use. On powering it up it was noticed that the +33.5V & - 33.5V supplies were not normal. A quick check with the oscilloscope showed the voltage across the two 2000uF filter capacitors was full wave DC ripple from the rectifier, as if the capacitors were totally open circuit. An ESR meter confirmed they were both indeed open circuit.

These two 2000uF capacitors were removed for inspection along with the apparently normal 6000uF 12V capacitor in the TM501 power mainframe. Physical inspection of the capacitors appeared normal and they felt to be a good weight. (Often a dried out electrolytic capacitor feels “light”). Therefore they were cut open. The interior contents were very moist and not dry at all. Inspection revealed that some foam latex rubber had melted and caused a chemical reaction that had corroded through the negative connections in the two 2000uF capacitors:




The 6000uF capacitor was also opened and although the strap connections were intact, in places where the latex had melted there was severe corrosive attack directed towards the inside of the aluminium canister. The photo above also shows the areas of corrosion in contact with the melted latex.

On connecting to the 2000uF capacitor's terminals, bypassing the corroded connection, both the 2000uF capacitors were perfectly normal with the uF value, leakage value and ESR well within specification.

Clearly this is not the fault of Tektronix, but a defect in the design of the Sprague capacitor. Although it would be clear to indicate in this case it was a near 40 year old capacitor. However, without the latex I think these capacitors would probably still be working fine.

**Discussion:**

When latex ages it either appears to become a fine powder or coalesce into a tacky brown liquid. Why this is corrosive toward metals is uncertain. In the case of aluminium if there is any contamination from halides, typically Cl- then the aluminium is oxidised:

$$Al_{(metal)} + 3Cl^- = AlCl_3 + 3e.$$

Perhaps it requires that the latex is contaminated with halide ions.

In any event the areas of melted latex in contact with either the aluminium canister or the strap connections to the capacitor elements were grossly corroded.

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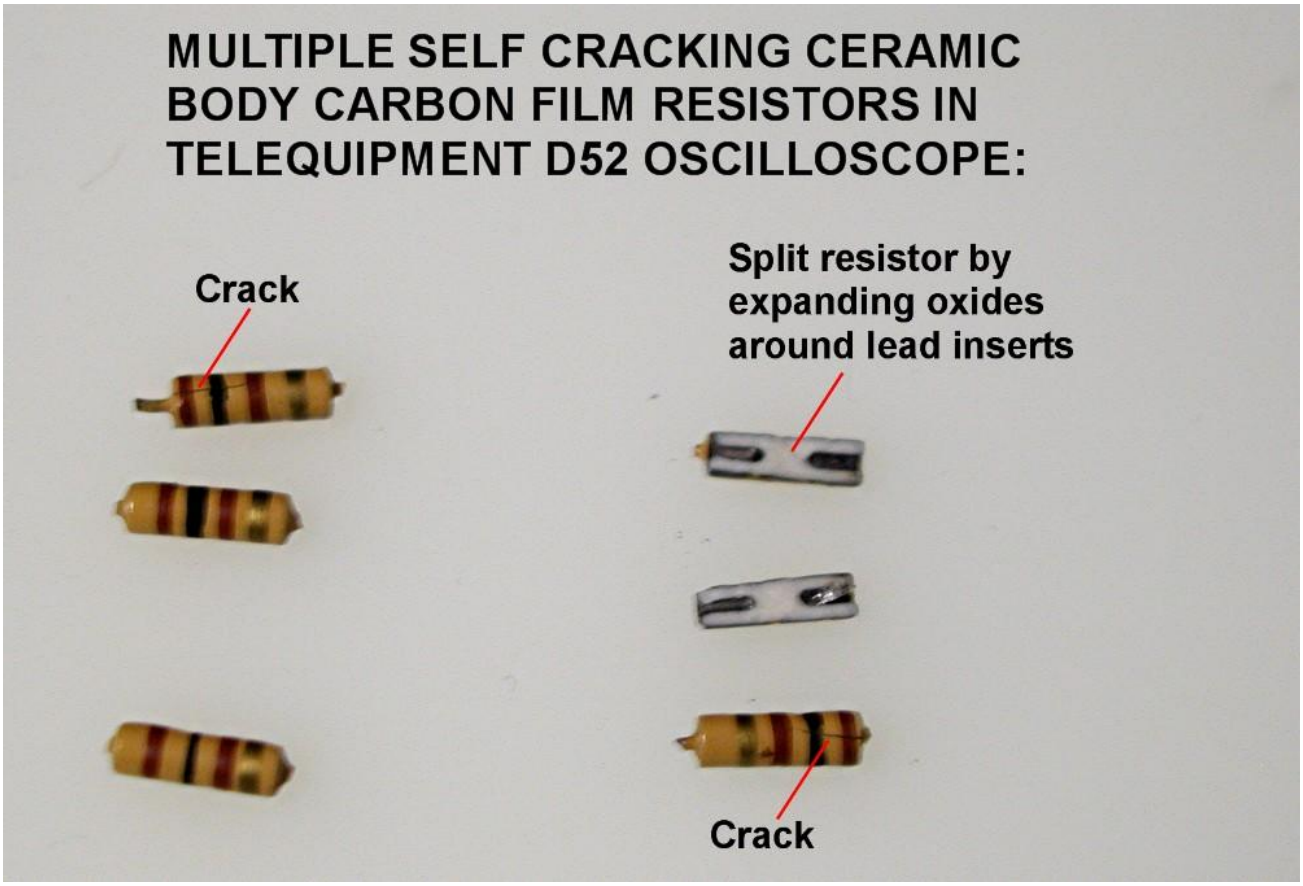
**Self Cracking Resistors in a Telequiment D52 Oscilloscope:**

A D52 scope, known to be working a decade beforehand was powered up to reveal multiple faults in the scanning and synchronization circuits. It turned out there was a particular brand of 100R resistors, six of which had gone open circuit. All of these resistors were used as “grid stopper” or RF suppression resistors in series with the grids of a number of tubes in the circuitry.

“Stopper resistors” in conjunction with the tube grid’s input capacitance form a low pass filter and therefore increases high frequency stability of the various amplifier stages and thereby stopping parasitic oscillations. The currents via these resistors are negligible, so the resistors had not failed due to excessive dissipation.

Inspection showed that the construction of the resistors was a little unusual. They have a solid cylindrical ceramic body, but rather than having end caps the lead wires were fitted into holes in each end of the ceramic cylinder which comprised the resistor’s body. Corrosion or oxidation of some kind had caused expansion around the leads creating migrating cracks in the ceramic resistor body. The carbon film was deposited on the exterior of the ceramic cylinder as is usual and with spiral calibration cuts. So for the resistor to go open circuit simply a crack had to pass across a short sector of the carbon film. One resistor separated into two halves with handling. A photo is shown below:



**Discussion:**

Oxides of metals or metal salts tend to expand in volume, so if they are encased in a rigid structure the pressure slowly builds up over time. A good analogy of the above problem is seen with amalgam fillings which develop corrosion on the surfaces mating up with the dentine in a dental filling. The pressure can build up and crack the cusps off the teeth, though at least the fillings do not work loose very often. Another example is rust crystals expanding under the paint on painted steel surfaces.

Clearly it is superior idea for a ceramic bodied resistor to have pressed on end caps rather than the wire inserts of the type shown above. Though most likely the creator of these resistors at the time had considered that they had produced a compact and streamlined looking component and were not aware of what could happen to it well over 40 years later.

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