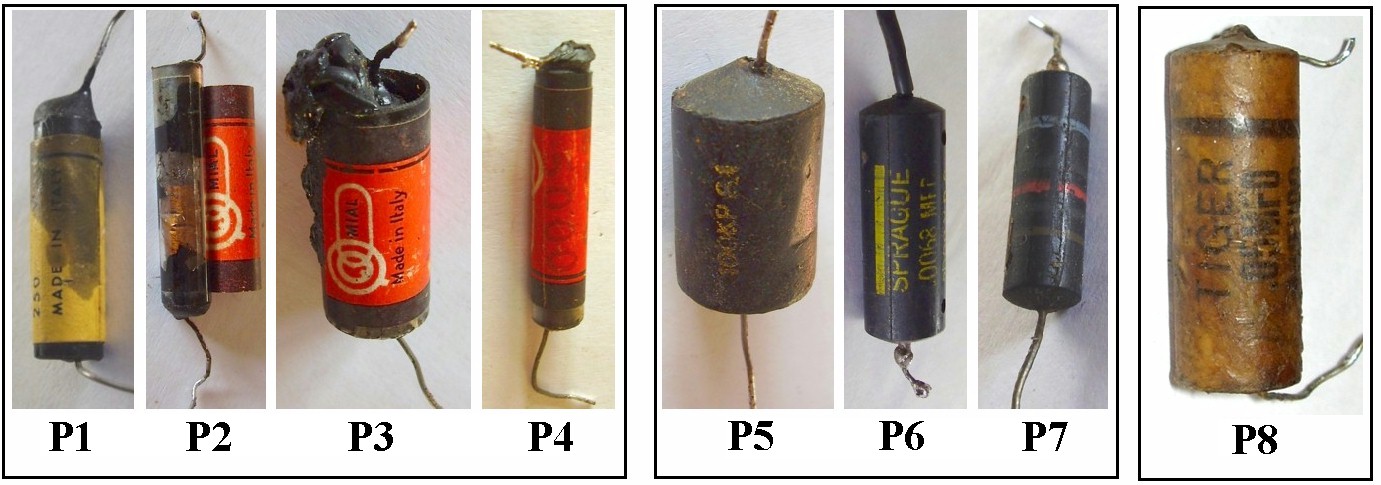
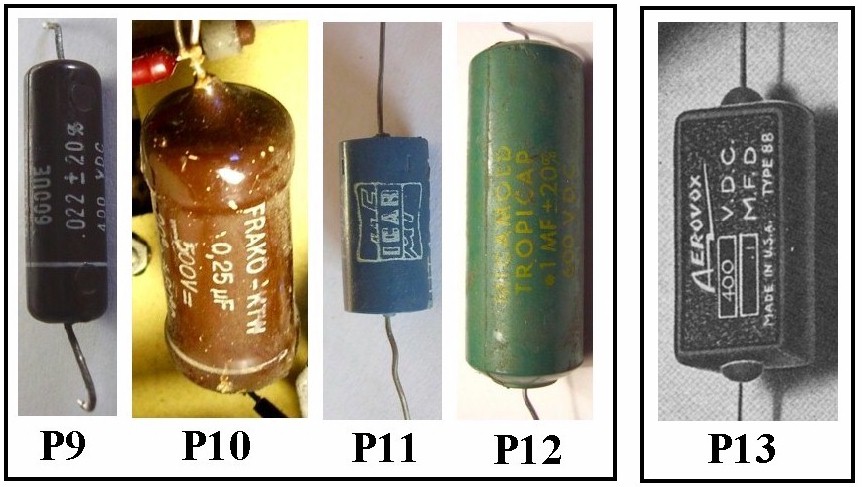
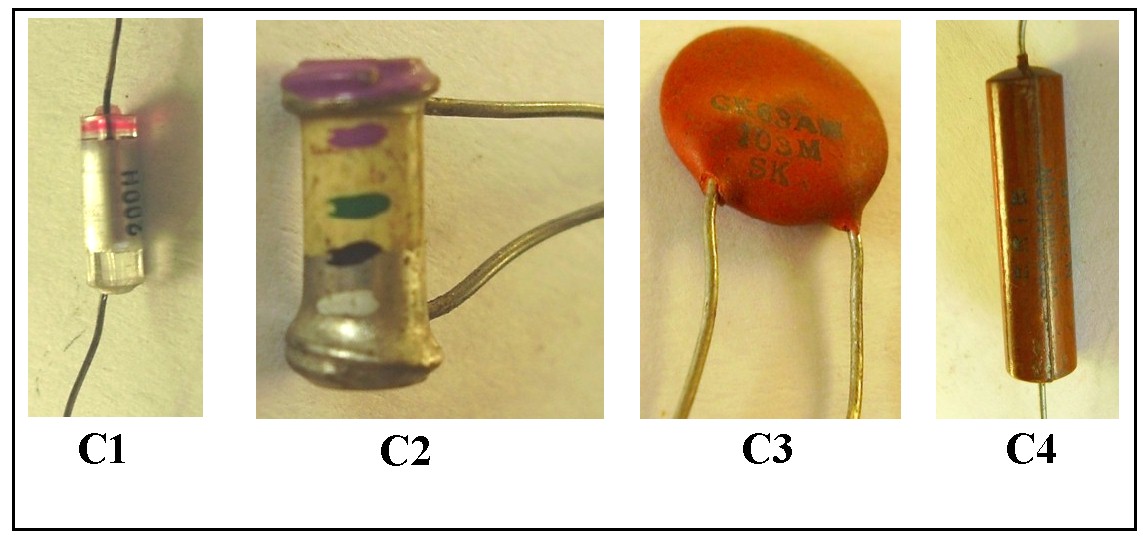
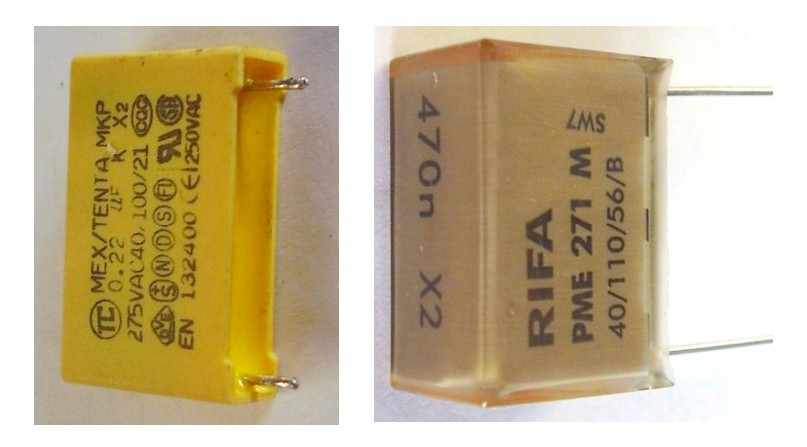
Common faults due to old capacitors  
  
Capacitors are responsible for many of the failures arising when trying to operate old equipment, grouped in the categories below.  
  
1) Short circuits.  
A short can be easily identified by low voltage and/or resistance values all around the faulty section. Often shorted caps cause other faults, as burned resistors or blown fuses. Whenever one of the latter conditions is encountered, shorted capacitor should be suspected unless different cause is found.  
  
2) Opens.  
This failure is common in electrolytic capacitors, when fully dried. If faulty capacitor is in the B+ filter section, a loud hum will arise. In some circumstances, such as in the cathode path of audio power amplifier tubes, a dried capacitor could also give benefic effect on sound quality. Opens can also be occasionally found in some polystyrene foil capacitors, due thermal stress on the leads.  
  
3) Drifts in capacitance value.  
These may derive from different causes: partial drying of electrolyte in aluminum capacitors; drying or alteration of impregnating oils or waxes in paper capacitors; moisture adsorption in ceramic or in paper dielectric; small cracks in silver coating of some lacquered mica capacitors, partial chipping of ceramic capacitors. A twenty-percent decrease in the capacitance of filter electrolytic capacitors may be tolerated, but a five-percent variation on the value of ceramic capacitors in tuned RF circuits may move resonance out of tuning range.  
  
4) Excessive leakage or low insulation resistance.  
A very high, but finite resistance value can be measured across any capacitor. In paper capacitors low resistance may be found because of moisture adsorbed by paper itself. Some leakage is acceptable in many circuits, as in decoupling paths of B+ distribution or in low voltage sections. In other cases, as in the coupling between AF driver and AF power amplifier stage, leakage can move grid biasing of the power tube to positive values.  
In electrolytic capacitors leakage is due to small holes in dielectric oxide. Leakage current starts quite high when capacitors have been left inoperative for a long period. In this case, if full operating voltage is suddenly applied, leakage current may cause irreversible failures. The dielectric layer can be easily repaired by a short reforming cycle.  
  
Dielectric types in old equipment  
  
Paper foil – Paper, usually impregnated with wax or oil, was used for general-purpose capacitors, ranging from about 1000 picofarads to over than 10 microfarads. It is still in use today, also in addition to plastic films, in many a.c. applications. Good paper capacitors stay still stable after over than 70 years. Some types or lots may give troubles in the years, due to poor hermetic sealing of their bodies, to poor manufacturing process or to unstable or hygroscopic impregnating fluids.

[](https://www.radiomuseum.org/forumdata/users/6435/capacitors/pic1.jpg)  
**Pic. 1 – Overview of paper capacitors. P1, P2, P3 and P4 are very poor types, with glass bodies and tar sealing. P1 and P3 show melted seals and P1 even lost its impregnating wax. P2 shows unstuck tar seal, P4 has swollen seal. P5, P6 and P7 are paper capacitors with molded bodies, sometimes hygroscopic through lead seals or small cracks. P8 is an excellent paper capacitor made around the mid ‘930s, with bee-wax coating: I performed 12 random checks on the many units used in my Hammarlund**[**SP110**](https://www.radiomuseum.org/r/hammarl_mf_super_pro_sp_110lxrsp110l.html)**(1937), always reading insulation resistance values higher than 100 megaohms.**

                         [](https://www.radiomuseum.org/forumdata/users/6435/capacitors/pic2.jpg)

**Pic. 2 – Although looking as paper types above, capacitors P9 to P12 use plastic films and insulation resistance is in the order of one gigaohm: no need for replacement, unless really defective! P13 shows an old paper capacitor with phenolic or rubber molded body: same look of many mica capacitors, but doubtful insulation if, since the ‘930s, Aerovox knew how critic the body molding process could be!**  
  
Mica – Mica, usually with silver armatures, was common in high-stability RF circuits. Body evolved in the years from molded thermoplastics to dip epoxy, but in Europe some types were just lacquered or even unprotected at all. Molded and dipped mica capacitors are usually reliable in the years.

[](https://www.radiomuseum.org/forumdata/users/6435/capacitors/pic3.jpg)

**Pic. 3 – Mica capacitors. Usually very reliable, particularly types M4 and M5. Some lots of the M3 type can be found out of tolerance, when silver layers are cracked and partially insulated from the leads. Note that the block packages of types M1 or M2 was also used for paper film capacitors: the identification of dielectric for capacitors with rectangular cases is not easy for capacitance values greater than few nanofarads.**  
  
Polystyrene (Styroflex) – Polystyrene film has low dielectric losses and good temperature stability. Polystyrene capacitors have been used in Europe as precision and stable components in RF and IF tuned circuits and in AF filters. Unfortunately this film does not withstand temperatures in excess of 82ºC and for this reason mica was preferred in United States. Reliability is very high, unless capacitors had been damaged by overheat.  
  
Ceramic – Ceramic capacitors were available for a wide variety of applications. Depending upon their composition, ceramic materials with different dielectric constant and controlled temperature coefficient were made. Low-capacitance, controlled temperature coefficient types have been commonly used in RF or IF tuned circuits. Medium to high capacity types found applications in interstage coupling or in RF decoupling filters. The reliability of ceramic capacitors is very high, although in some cases their capacitance may be altered by adsorbed moisture; usually capacitance recovers its value after a short baking.  
                      [](https://www.radiomuseum.org/forumdata/users/6435/capacitors/pic4.jpg)  
**Pic. 4 – C1 is a polystyrene capacitor. C2 to C4 are typical ceramic capacitors.**  
  
Electrolytic – In electrolytic capacitors a thin oxide layer acts as dielectric between aluminum foil inside and electrolyte paste. Electrolytic capacitors are usually polarized and oxide may easily be destroyed by polarity reversal or by overvoltage. Common failures include oxide perforation or shorts, often triggered by excessive leakage currents, and low capacitance, due to dried electrolyte. Electrolytic capacitors should be replaced if their capacitance falls under 80% of the nominal value. The oxide layer can be partially etched when the capacitor is left inoperative for a long period. The oxide layer can be reformed, applying a reduced voltage for a while, in order to limit leakage currents to safe values at the beginning. Otherwise excessive currents may cause harmful temperature rise with electrolyte escaping from the vent hole and further current increase, up to the destruction of the oxide layer.  
                            [](https://www.radiomuseum.org/forumdata/users/6435/capacitors/pic5.jpg)  
**Pic. 5 – These capacitors show visible traces of electrolyte leakage and should be replaced.**  
  
  
Some tips  
  
Capacitance meter and insulation meter are usually required to trace faulty capacitors. Common multimeters are useless to measure insulation resistance. No need to buy expensive instruments, since approximate measurements give a good indication of the fault. I found suitable insulation   
When measuring the value electrolytic capacitors, one should remember that –20 to +80% initial tolerances are quite common for these components.  
  
When first handling any old equipment it is advisable to perform some preliminary operations before replacing components. After a good cleaning, a visual inspection returns a first list of damaged parts, as hardened rubber cables or cracked capacitors that must be replaced before power-up. As general rule, if the equipment was stored for a long while, six months or more, regardless of its previous operative conditions, a soft wake-up procedure should be run to allow reforming of electrolytic capacitors and of selenium rectifiers, if any. It is advisable to run equipment at about half voltage for half an hour, monitoring B+ voltage and watching for fluid losses from electrolytic capacitors, for overheat of components, hum and other alarming conditions.  
  
No need to replace all capacitors. Some are used in low voltage, medium to low impedance paths and their operation is not impaired by small leakage. Good prewar paper capacitors still today have an insulation resistance in the order of several tens or hundreds of megahoms. Other capacitors, looking more or less as paper ones, use mica or plastic films and their resistance is in the order of 1000 megahoms.  
  
The replacement of paper capacitors requires careful evaluation of the circuits where they were mounted. Paper dielectric material performed fairly well in AC applications: polyester film is not as good as paper in the same job. Whenever possible film-foil or polypropylene film capacitors in a.c. applications inside the equipment should be preferred. It is the case of capacitors across the primary winding of output transformers, of small a.c. motor run capacitors or of filter capacitors across high-voltage windings of the power transformer. In power line filters only UL/CSA/IEC approved film-foil or ceramic capacitors should be used.  
                            [](https://www.radiomuseum.org/forumdata/users/6435/capacitors/pic6.jpg)  
**Pic. 6 – Some X2 film-foil capacitors approved for safe use across a.c. power line.**