Part 4 - Repairing Broken Condensers

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If you have read the earlier sections of this Technical Series on Condensers, you'll recall that your REALLY old condensers (manufactured in the 1910s through 1940s) were all built with wax paper / tin foil construction. The "wax" in these condensers tended to "dry out" and fail after just a few years of operation, allowing electrons to "arc" between the tin plates of the condenser, causing all kinds of ignition problems. In the 1950s, Polystyrene, Polyethylene and other plastic films were developed, and these were FAR more reliable than the old Wax Paper construction used earlier. Condensers manufacturers all switched almost immediately to building condensers with these new plastic films, with aluminum foil replacing the earlier tin foil construction. These new condensers were FAR more reliable than their predecessors….at least initially!

Unfortunately, the market evolved to a "smaller is better" way of thinking, and the condenser manufacturers starting making their condensers as small as possible. To do this, they had to use VERY THIN layers of plastic film and aluminum foil. (TOO thin, as far as I'm concerned!) The result of this is that the plastic films tend to chemically fall apart, under a combination of physical stresses, the presence of water vapor, and the stress of the high voltages across the films. It takes a few years for this to happen, but the bottom line is that many condensers that SHOULD last for 40 or 50 years once again have a 4 or 5 year service life (just because of how small they are made, and the construction techniques used.) Aggravating the situation are the really cheap, low-quality condensers manufactured in India and China, that seem to have flooded the market in recent years. (Yes, there are a few QUALITY condenser manufacturers that still exist in the world, but they often don't have condensers available for REALLY old, antique outboards…..they tend to stock only the most popular sizes.)

So, what can be done about this? Well, if the condenser in your old outboard is physically large, you can rebuild it, using a new, high quality "film capacitor".
On the AOMCI Forums and Members Board, several members have shared pictures of how they have "hollowed-out" bad condensers, and put a modern Polyethylene capacitor inside of it to "rebuild" bad condensers. This is a fairly common practice; heck, I've done this myself. **However, I've noticed that many of the condensers that were recommended on the AOMCI Forums and Member Board were actually not specified correctly, and would highly likely fail in a very short amount of time.**

The series of film condensers I personally use to "rebuild" the larger wax paper and standard condensers are the MKP1839HQ series, from Vishay. For most outboards, a 0.22uF condensers is needed, so the part I most often use is:

Mylar Condenser: 0.22uF 5% 850VDC AXIAL Metal Film
Vishay BC Components type: MKP1839422084HQ
DigiKey part number: BC2609-ND (About $3.50 each)

If you go to the DigiKey web site and look up this condenser, you will find that it has a DC rating of **850 volts.** Many people think this is way more than is needed…..but look at the AC voltage rating, and you'll find that it's only rated for **400 volts AC.** (If you read Part 3 of this Condenser series, you'll know **that it's quite common to see 400 volts peak-to-peak across your points….and even slightly higher, on some outboards. It's this AC rating that really matters, and 400V is on the low side. So, the Vishay MKP1839HQ series is the LOWEST grade of condensers I would recommend.** Note: these Vishay parts are not all that small…..so you can only "repair" your larger condensers using this technique. (But, it DOES work REALLY WELL!)

Here's the process I use to rebuild the larger old condensers. (See Fig. 1, below):

(1) Drill out the body of the old condenser. Remove ALL pieces from the old metal can.
(2) Select an appropriate replacement mylar cap.
(3) Drill hole in bottom of can, and insert new cap.
(4) Solder wires onto new capacitor, and re-seal the metal can with a good epoxy.

Fig. 1 - Rebuilding Film Condensers

However, as I noted earlier, many condenser manufactured their parts as small as they physically could (either very SHORT, or very small in DIAMETER, so they could fit into tight applications.) These Vishay MKP series only fit into about 1/3 of the condenser cases…..they simply don't fit into the "stubby" and small diameter condenser cases.

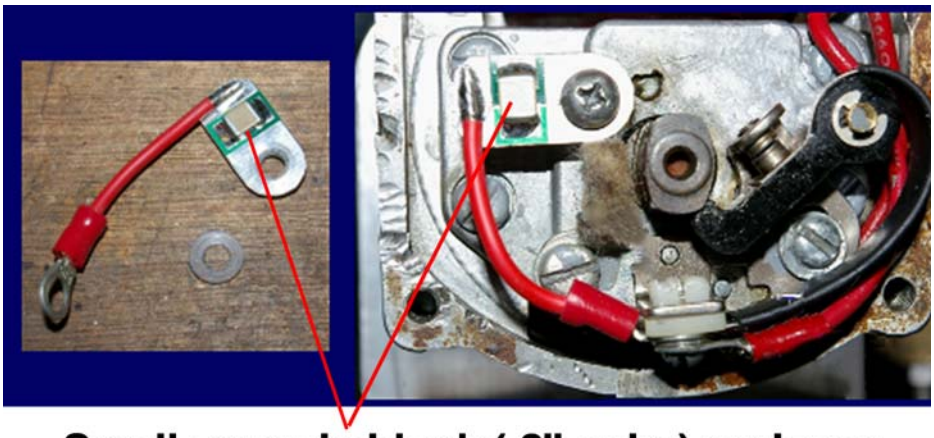
So, are we condemned to this perpetual nightmare of finding shorted condensers every few years? Well.....actually…...no! **Mylar film isn't the only good "dielectric" out there.** Let's take a look at some of the options. (See Fig. 2, below).

Material	Dielectric Constant "K"	Dielectric Strength (in V/um)	Dielectric Constant x Dielectric Strength (mid range)
Air	1	3	3
Wax Paper	4	40 - 60	200
Mylar Film (Polyethylene)	3.4	80	270
Mica	5	120	600
X7R Ceramics	1,000 to 4,000	75 - 150	280,000

Fig. 2 - Capacitor Dielectric Characteristics

Look closely….**there's a new entry in the list of options....."X7R Ceramics"!** Now, X7R Multi-Layer (MLCC) capacitors have been around for decades, but....they typically have had a working voltage of 20 volts or less. There just wasn't any motive for anyone to make a high-voltage X7R Ceramic condenser....until one company did, about 15 years ago. These became VERY popular with power supply designers, and the demand shot through the ceiling for higher and higher voltage X7R condensers. Several high-quality ceramic capacitor manufacturers got into the market, and suddenly there's a new family of capacitors to play with.

About 10 years ago, MuRata Erie (a very high-quality Japanese capacitor manufacturer) designed and built several models that not only have the capacitance needed for outboard magnetos, they have the voltage tolerance to go along with it. Several other capacitor companies quickly jumped into that same market with competitive products. So, why haven't these been used in automotive / marine applications yet? Well, actually, they HAVE been, although only in a very limited "specialty" niche market. There's a company in Sydney, Australia called "BrightSpark Magnetos", that is building "conversion kits" that allow users to use X7R capacitors INSTEAD of standard magneto condensers. See Fig. 3 for an example:



Small ceramic block (.2" cube) replaces traditional large metal can condenser.

Fig. 3 - "Ceramic Block" Capacitors

Check out Bright Spark on the web! See: http://brightsparkmagnetos.com/

Now, BrightSpark's market is aimed at more traditional magnetos (from Bosch, Lucas, Fairbanks Morse, etc), instead of the "flywheel magnetos" used in antique outboards. They do have patents covering their 'Easy-Cap" parts....but, there's nothing that says we can't use these same X7R capacitors, to "rebuild" a few bad condensers for our antique outboard applications, is there? Well, there's nothing that says we can't, and because these ceramic elements are SO MUCH SMALLER than any film capacitor alternative, it's now very easy to rebuilt almost any size metal can condenser. **However…..these X7F ceramic elements are FRAGILE, compared to Film Capacitors, and subject to corrosion unless they are protected.** (Fortunately, we can take steps to "harden" a XR7 chip so it will last a long time.) Let's look at how this can be done. Here's the process I personally use (again, assuming a 0.22 uF condenser size. Order the correct VALUE for your particular application!)

Suggested parts for a 0.22uF rebuild:

CAP Ceramic, 0.22uF 1KV X7R 2SMD
Murata Electronics type: KRM55TR73A224MH01K
DigiKey part number: 490-14687-1-ND (About $3.30 each)

CAP Ceramic, 0.22 uF 1.2KV X7R 2220
Knowles Syfer type: 2220Y1K20224KXTWS3
DigiKey part number: 1608-2220Y1K20224KXTWS3CT-ND
(About $6.70 each)

These ceramic elements are TINY, compared to their Mylar Film counterparts. Take a look at how small they are, compared to the Vishay Mylar Film capacitors. Note how the Mylar Film condenser core probably can NOT fit many of the short, or narrow, condenser cases….which should be easy for the X7R "chip" caps. (In the picture below, the film condensers could not fit in the "stubby" cases, or in the brass Phelon cases either.) So, let's look at the steps needed to rebuild condensers using X7R ceramic elements! Refer to Fig. 4 to see how these Ceramic elements will fit almost any application!

Fig. 4 - Size Comparison

Just like before, we'll start by drilling out, and removing the old (shorted) Mylar condenser "core". We'll then replace it with the X7R "chip"….but, because of how fragile these ceramic elements are, we'll have to go to some extra steps to "harden" the assembly for it's intended application!

See the photos and comments on the next two pages, Fig. 5 and Fig. 6, for details on how to rebuild condensers with X7R Ceramic Capacitors:

Get a collection of dead (shorted) condensers to modify.

Using side cutters, cut the lead wire off as close to the condenser body as possible.

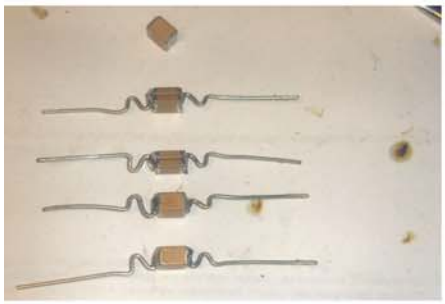
Use a 1/8" drill bit, and drill as many holes as you can, as close to the bottom of the condenser as you can. (Large drill bits cause the core of the condenser to "grab" and spin around, and NOT cut!)

Next, use a small (but strong) pair of needle-nose pliers to pull all of the pieces of the core out of the condenser.

Clean absolutely everything out of the cases; make sure nothing remains.

Drill a 1/16" diameter hole in the bottom of the condenser case. (This is for one of the lead wires to exit the case.)

Fig. 5 - Rebuilding With Ceramic Caps, Part 1



Cut the leads off of some 1 Watt resistors. Solder these leads to the X7R capacitor "chips". Then, bend an "S" pattern into the leads, to allow some strain relief.

Coat the X7R ceramic "chip" with a layer of 15-minute plastic epoxy. Do not cover the "S" pattern in the wires, as that would defeat their "strain relief" capability.

Wait a few hours for this to cure.

Insert the coated X7R chip and lead assemblies into the empty condenser cases. Thread the bottom lead through the hole in the bottom of the case.

Turn the case upside-down. Bend the lead over flush with the bottom of the case. Cut the lead about .2" long from the hole in the case. Then, solder the lead to the case. Flow the solder around a bit to "feather" it in, hiding the wire.

Use silicon sealer (or any other soft sealing compound) and fill the case up to within .2" of the top of the case.

Wait 24 hours for the sealer to cure.

Mix up a batch of epoxy (I use JB Weld). Fill the rest of the case up to the top. Wipe with paper towel, to smooth the epoxy out. Wait another 24 hours to cure.

Your condensers are now ready to use!

Fig. 6 - Rebuilding with Ceramic Caps, Part 2

It may not be obvious why I coat the ceramic “chips” with epoxy as a separate step. The reason I do this is because when you solder the lead to the bottom of your old condenser’s case, the heat can easily cause that wire (which is also soldered to one side of the ceramic cap) to so hot that the solder on the ceramic cap melts, and the whole assembly falls apart. Coating the X7R "chips" and their metal wire leads in epoxy makes them look like a “dipped tantalum capacitor" (if you know what that looks like!)...and the epoxy then holds the wires to the case, even if they momentarily get so hot that the solder holding them to the ceramic caps actually melts. This saves a lot of hassles when soldering to the bottom of the old condenser cans. This epoxy coat also keeps the capacitor “chips" from “shorting out” to the insides of the old condenser cans!

There’s another reason for this epoxy coat, and that is that many of your flexible “sealers" contain corrosive ingredients that can harm the ceramic elements. If you use traditional “silicon sealers” for your sealing compound, most of them use ascetic acid, which gives off a strong vinegar-like smell when curing. Other sealing compounds use chemicals in their formulations that are even more corrosive than that.....and this epoxy overcoat protects the X7R elements from anything that might be in your flexible sealing compound.

This “rebuild” technique should allow you to rebuild almost any condenser, if you are willing to go through the trouble of doing all that work. But, they SHOULD last for a very long time. According to BrightSpark’s website, they have shipped about 3,000 of these X7R-based condenser replacements, with ZERO failures over a 3 year period. In addition, they have tested dozens of them on “magneto simulators", running them 24 hours a day for that entire 3 years….also with no failures. (That’s not long enough to predict how long their entire service life is going to be in magneto applications, but I’m guardedly optimistic that they’ll last longer than any mylar film condenser in these applications!)

Now, my instructions (above) show how to “rebuild” a metal can condenser, so it will LOOK LIKE THE ORIGINAL EQUIPMENT when you are done. Obviously, if appearances are not important to you, then putting the ceramic element in a metal can is just “overkill”. You CAN just solder short lengths of stranded wires to the ceramic elements, and perhaps put a bit of “heat shrink tubing” around them for insulation, and then install them in any motor you want. (They will be under the flywheel, and won’t be seen……so if FUNCTIONALITY is all you care about, you can save yourself some effort and time here. But, if you’re really fussy about appearances, then go ahead and “fix” the metal cans, so the system looks like the original equipment when you’re done.)

One last note: the ceramic capacitors (encapsulated the way I did it here), will “leak" a tiny amount of current. On your “condenser insulation breakdown testers", you might see an occasional *very faint* “flash" on the "Fail" neon lights...perhaps every 5 seconds or so...but, in fact, this tiny amount of leakage current is so low that it has no effect on a magneto’s operation. With an X7R, your “condenser insulation breakdown tester” will either have the "Fail" neon light glow CONTIUALLY (indicating a shorted element,

which is bad), or it may flash VERY INTERMITTENTLY…perhaps 5 seconds apart or more..(which is OK, for a X7R, encapsulated the way we did it in this procedure).

Give these X7Rs a try, and let me know how they work out in your applications!

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