

# BUILDING AN ELECTROLYTIC CAPACITOR

## APPLICATIONS

A capacitor is an electrical component that stores a quantity of electrical charge defined with a linear relationship as:

$$Q = C \times V$$

where:  $Q$  = electrical charge [Coulomb]

$C$  = Capacitance [Farad]

$V$  = Voltage [Volt]

Usually values are indicated in a smaller unit called micro Farad [ $\mu\text{F}$ ] that is one million times smaller. An aluminium electrolytic capacitor is composed of one anode of aluminium foil (or one aluminium foil anode) having a dielectric oxidation on its surface, with semiconductor characteristics to prevent the current flow in one direction, and another aluminium foil cathode. There is also an electrolyte impregnated paper layer positioned between the anode and the cathode in order to avoid short circuits. Both the aluminium foils have been etched to obtain active surfaces, increasing their effective area. Aluminium tabs are then connected to the two foils to act as terminals. When in use the impregnated section is then closed inside an suitable case and sealed with a deck. The matching of thin dielectric and a large surface area allows to create capacitors with exceptional high capacitance per volume.

European (CECC) and International standards (IEC) have classified the capacitors in two categories. Electrolytic capacitors for high reliability applications (Long Life Grade): in addition of the possible over anodization (the difference between forming voltage and operating voltage) must generally satisfy high endurance requirements and a careful selection on materials is needed.

Such efforts are not required for capacitors standard version used for less severe reliability (General Purpose Grade).

The whole manufacturing process requested to build a Kendeil electrolytic capacitor could be reasonably split into the following phases:

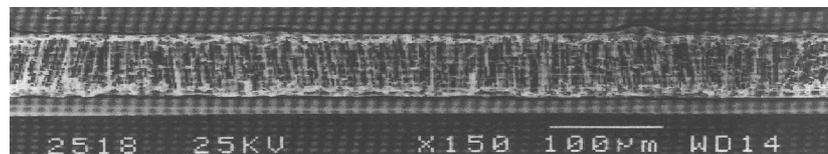
- \* Etching
- \* Winding
- \* Impregnation
- \* Sealing
- \* Ageing
- \* Production Inspections

## ETCHING

Plates or electrodes are made of high purity, very thin aluminium foil (0.05 to 0.1 mm thickness). To get the maximum capacitance for a given electrode surface area, an electrochemical process called "etching" is used to dissolve metal and increase the surface area of the foil in the form of a dense network of microscopic channels.

The etching process consists of continuously running aluminium foil through a chloride solution with an AC, DC or AC/DC voltage applied between the etch solution and aluminium foil.

The increase in surface area is referred to as foil gain and can be increased as much as 100 times for foil being used in low voltage capacitor applications and 20 to 25 times for higher voltage applications. The dielectric of the aluminium electrolytic capacitor is composed of a thin layer of aluminium oxide ( $\text{Al}_2\text{O}_3$ ) which "forms" on the surface of the etched aluminium foil during a process called "formation."



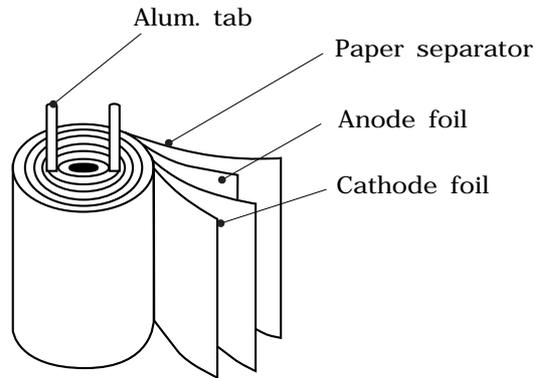
MICROGRAPHS VIEW OF ETCHED ALUMINIUM FOIL

Since capacitance is inversely proportional to the dielectric thickness and this is proportional to the forming voltage, the following relation is applicable:

$$\text{Capacitance} \times \text{Forming Voltage} = \text{Constant}$$

This is true for high voltage foils with a relatively coarse etch structure. However, for foils with extremely fine structures, the process to convert aluminium to aluminium oxide has a significant smoothing effect on the structure that might be described by a non-linear relationship.

## WINDING



### THE CAPACITOR ELEMENT

Each capacitor contains two foils, the positive foil is called the ANODE and the negative is called the CATHODE. Both foils, along with a separator paper are rolled into a cylinder.

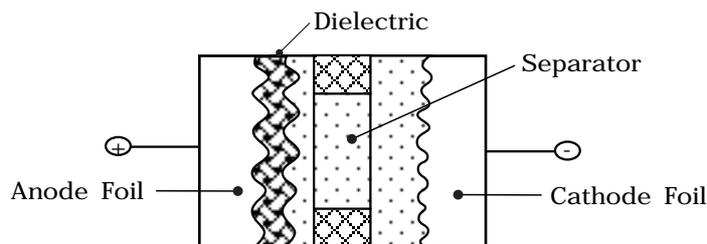
The separator paper prevents anode and cathode foils from coming into contact with each other and shorting. As part of a highly automated winding process, aluminium tabs are attached to the anode and cathode foils. This completed assembly of etched and formed foil, together with separator paper and attached tabs is called the capacitor ELEMENT.

## IMPREGNATION

The method of impregnation requires the winding element to be immersed into the electrolyte by either a vacuum/pressure cycle with or without applied heat or by simple absorption.

The electrolyte contains a solvent such as ethylene glycol and a solute such as ammonium borate.

Should the dielectric film be damaged, the presence of the electrolyte will allow the capacitor to heal itself by forming more oxide. By selecting different electrolytes, the capacitor characteristics such as operating temperature range, frequency response, shelf life and load life could be improved.



The cross section for a typical element

## SEALING

After impregnation phase, the element is sealed into an aluminium can. Sealing deck materials may be rubber/bakelite or phenolic plastic.

## AGEING

Before being sleeved and packed the capacitor is aged and tested, this being the final process of the production chain, usually called "ageing". A voltage greater than the rated voltage is then applied at very high temperatures. The purpose is to reform or to repair any oxide film which may have been damaged during the slitting, winding and assembly processes, thus reducing the leakage current to an acceptable low level.

## PRODUCTION INSPECTIONS

After ageing, capacitors are 100% tested. All electrical requirements are checked using highly advanced automated test equipment and any rejects are removed. Capacitors are also visually inspected, and only capacitors passing both tests are accepted for packaging.