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The Ideal Transformer Encapsulant

This paper was written by our good friend and mentor, the late Mr. T. W. Kolator P.Eng whose knowledge and wisdom helped us to develop some of our best products for the encapsulation of instrument transformers.

This page of our web site and this article is dedicated to his memory.

Tadeusz Kolator wrote:

I thought that it might be useful to outline some properties of an encapsulant for use in casting Instrument Transformers or bushings. I shall list properties and give short explanations or reasons for their desirability in these applications.

1. **Dielectric Strength about 400 v/mil**

   This value, although it may seem quite low as compared with many insulating materials of today, is quite sufficient for our application. Higher values would not be of any advantage, as a matter of fact, it would be very difficult to utilize it. Designs with higher stresses than 400 v/mil would create even greater problems with partial discharges and radio interference. Also, because of low creepage and jump distances in the air, external clearances would still have to be maintained regardless of the dielectric strength of the encapsulant itself.

2. **Dielectric Constant As Low As Possible**

   Ideally it would be best to have dielectric constant equal to that of air (namely K=1). However, as this is impossible, we have to accept fairly high values, but the lower they can be the better it is. The higher the value of K the more difficult it is to meet required ionization levels. Also, it may cause surface flash-over in some configurations.

3. **Low Viscosity at Pouring Temperatures (say about 3000 cps or lower)**

This is important for the following reasons:

a. ease of filling all small crevices and spaces thus providing good electrical insulation.

b. ease of releasing trapped air bubbles

c. the time of pouring can be shortened

d. pouring can be done through small openings

e. better homogeneity of mixture can be obtained

CAUTION: settling of filler has to be kept to minimum

4. **Low or No Shrinkage**

This is extremely important in the case of casting Current Transformers. Electrical steel characteristics (losses and magnetizing current) change with pressure exerted on the core effecting intern, accuracy of the transformer often shifting it beyond limits of acceptance. Also, with no shrinkage there wouldn't be any stresses in the castings and as a result, there would be a lower chance of cracking.

5. **Flexibility - Elongation**

Same reasons as under point # 4 above. Stresses on cores can be eliminated if the shell cast is flexible enough, there would be no cracking. The desired elongation is in the order of 40%+.

6. **Thermal Expansion**

Ideally it should match that of electrical steel (core).

7. **Tensile Strength**

Preferably should be above 2300 psi or perhaps, still better, it should have low tensile strength but have high flexibility elongation with a very high ultimate yield point (similar to rubber).

8. **High "Green" Strength**

Sufficient strength should be reached by the encapsulant prior to de-moulding otherwise internal damage, often not visible, can be done to the encapsulant resulting later on, probably in service, in cracking of the shell. High "Green Strength" would make de-moulding easier and faster.

9. **Low Temperature Cure (preferably R.T.)**

a. energy saving

b. ease of handling

c. no need for oven facilities

10. **Good Adhesion**

This feature is extremely important in both, transformers and bushings in order to prevent:

a. oil leakage

b. creating voids by separation (pulling away)

c. reduction in the strength of the moulded body

11. **Compatibility with Transformer Oil**

This is important not only with respect to the cured encapsulant which may be used immersed in oil, but also prior to cure. Some processes involve casting oil impregnated equipment and this oil must not effect the curing encapsulant.

12. **Tracking Resistance**

This feature is important especially for outdoor use. Having Alumina as a filler or part of the filler improves this feature.

13. **Resistance to Chalking (ultraviolet)**

Chalking caused by exposure to sunlight effects appearance and, as some claim, lowers the self cleaning abilities of the exposed surface.

14. **Gel Time**

The preferred gel time is around 1-1/4 to 1-1/2 hours.

15. **Boiling Point**

In view of the fact that some encapsulations will be carried out at very low vacuum, even below 1 mm of Hg, it is essential that very little, if anything, should come out of the mix. Stripping any ingredients from the mix could effect the properties, entrap vapours and cause non-uniformity in the casting.

16. **Surface Tension**

The surface tension should be such that it is easy to remove bubbles and the material will readily flow into small spaces.

17. **Low Toxicity, Odourless**

Safety reasons, ease of handling without the necessity of excessive precautions.

18. **Thermal Shock**

The cured encapsulant should be able to withstand temperature variations at an approximate rate of 34^{0}C/hr. The usual temperature range is between -45^{0}C and $+100^{0}$C for a minimum of 12 cycles.

19. **Outdoor use - Weathering**

The fillers contained in the encapsulant must be carefully chosen, selecting closed-cell, non-absorbing filler types. Any moisture absorption initiates erosion of the casting and can cause changes in the electrical characteristics.

20. **Aging**

The aging properties must be such that an acceptable level of physical properties are maintained in service for a period of at least 20 years.

21. **Flammability**

It is desirable for the product to be flameout or at least a type that does not support combustion.

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This article is posted verbatim as given to us by Mr. Kolator in April, 1980. The above concepts were instrumental in the development of our CLC 15-150 compound and its derivatives for the encapsulation of instrument instrument transformers.

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Send mail to Webmaster info@crosslinktech.com with questions or comments about this web site.
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