FILTERALL LIMITED

This paper reviews the present state of knowledge regarding the treatment of transformer oil by various separation and purification techniques. Latest knowledge dictates that the plant should be mobile to allow movement between sites and processing be made at the transformer in order to provide maximum benefit.

1.0 Filtration, degassing and dehydration is generally accepted as purification and the most modern processes utilise a combination of Thermo-Vacuum Treatment and Highly Efficient High Dirt holding capacity disposable Filter Cartridges.

1.1 The main purpose of transformer oil Purification equipment is to remove solids, (1 micron being the acknowledged maximum particulate size acceptable in Transformer Oil), remove gases present in the oil and to remove moisture from the oil. The latter two being products of oxidation which contribute to the so-called aging of transformer oil.

1.2 Filterable mechanical particles of 0,1 micron and larger are considered to be of non-colloidal character and are usually formed as a result of degeneration of the cellulose insulation itself or contamination occurs during the filling stage of the transformer. Often particles remain in the transformer from the manufacturer. Solid particle contamination and their influence on dielectric strength of transformer oil has been given more attention in recent years and modern Filtration Cartridges capable of removing particles down to 0,5 micron are now preferred for transformer oil filtration.

1.3 Thermally accelerated Vacuum Dehydration and Degasification of Transformer Oil has gained wide acceptance as the most economical method for the removal of dissolved water and gases. The following factors influence dehydration and degasification by vacuum treatment; oil temperature, absolute pressure in the vacuum chamber and time of oil exposure to vacuum, and the surface tension of oil.

The basic concept of Thermo-vacuum treatment being that oil is introduced via a heater into the vacuum chamber where exposure of the oil is accelerated releasing moisture and gases which are then evacuated through the vacuum pumping system. Actual design of this system includes a variety of auxiliary equipment and monitoring instrumentation to maintain safe and reliable continuous operation. The degree of control being evident in that to days' plant are designed to facilitate unattended operation.

Exposure of the oil to Vacuum can be made via various methods. Maximum oil surface exposure to the effect of vacuum for a certain length of time is the important factor in effective removal of dissolved water and gas.

Spray Nozzle method has been used and when this method is applied, the finer the spray the larger the relative oil surface but at the same time the higher the surface tension in the oil droplet. This method is no longer considered satisfactory today because due to relatively high surface tension, the release of water and gas is limited and multi-pass treatment is required to achieve acceptable levels of both.

Rashing Rings method, similar to spray nozzles is also no longer acceptable because of the

difficulty in achieving the required oil film spread on the surface of the rashing rings.

Centrifuge Bowl spray method gives more satisfactory results than the previous methods and is particularly advantageous with heavily contaminated, (water and particular), heavy oils. However, with existing viscosity of transformer oil it is not possible to achieve the oil split required in order to achieve the low moisture and gas figures required for transformer oil and consequently multi passes are necessary. Centrifuges are a mechanical means for spreading free and suspended contaminants such as carbon, water, etc. in heavily contaminated oil only. The centrifuge however, can not remove dissolved water or finely divided carbon, thus the oil leaving the centrifuge is not considered suitable for re-introduction into transformers unless the process is followed by other processing equipment. Generally speaking, transformer oil does not get so heavily contaminated whilst in service, to warrant centrifuge treatment prior to other processing methods. If oil is that heavily contaminated the oil must be regenerated using Fullers Earth which is the only successful method to recycle heavily contaminated transformer oil.

Fiberglass Coalescing Method is the best and latest method of spreading the oil inside the vacuum chamber. In this method, oil enters the vacuum chamber through a fiberglass element, where it spreads over a large area when passing through a thick layer of fiberglass shell. Glass fibers of 3 to 8 micron diameter expose each kg of oil to a corresponding surface of up to 500 m2. In addition to this large surface of oil exposure to vacuum, the presence of millions of sharp ends of glass fibers contributes to the evolution of the gas from the oil and to the break-up of gas bubbles.
In practical terms, the preferred method of Dehydration and Degasification via Thermo-Vacuum Treat, when using the Fiberglass Coalescing Method of subjecting the oil to vacuum, will enable Water Removal from 50ppm down to 5ppm in a Single Pass (and down to 3ppm after two passes) and Gas Removal from fully saturated with air (10 to 12% by volume) down to less than 0,1% by volume.
Heating of the oil is a critical part of Thermo-Vacuum treatment and the desired method of heating is via Low Watt Density Heaters (to eliminate harmful effect of overheating the oil). The heater should also be designed to transfer heat in a uniform way in order not to create hot spots and damage to the oil. In the cases when some sludge is present in the oil however, and regeneration equipment is not available, it is often advantageous to bypass the Vacuum chamber for the first pass and to treat the oil with the heaters off. This will inhibit the sludge from being absorbed into the oil and enable the filters to more easily extract more of the sludge than if the oil was heated to normal processing temperature.

2.0 New concepts and equipment for field treatment of highly contaminated transformer oils, due to aging or equipment failure are also available and discussed. These processes are basically absorptive treatments using fuller's earth followed by a filtration and thermo-vacuum process which **regenerates** / recycles the oil to a state equal to that of new oil. The Fullers Earth treatment will remove contaminants such as acidity, sludge and other decaying products providing improved oil colour and oxidation stability.

2.1 Latest technology provides for total oil regeneration and utilises the latest Process Control and Automation via a computerized plant supervisory system. This allows processing to be carried out on energised or de-energised transformers ensuring a total cleaning of the transformer inner and windings. Processing from tank to tank provides regeneration of contaminated oil to same standard as new oil (BS148) in one pass.

The most effective method of transformer oil regeneration is on site and within the transformer. This can be carried out on energised or de-energised transformers. Resent technology has been introduced to the industry which allows for the Fullers Earth to be permanently installed in the oil treatment beds. In this method, when the Fullers Earth is saturated and no long actively absorbing contaminants, the clay itself is the reactivated within its housing and can be utilised for

many years before it begins to drop in efficiency notably as to warrant replacement. The need to dispose of oil soaked contaminated clay doesn't arise and when clay change is considered the clay is disposed in a sterile dry powder form which has no adverse effect on the environment. This development has made Transformer Oil Regeneration a viable economic treatment and the processor enjoys an immediate high return on his investment due to the typically very low operating costs.

On-Site Transformer Oil Regeneration is the most profitable as not only does it regenerate the oil within the transformer, but it actively regenerates the Transformer by removing impurities which buildup within the transformer.

It is generally agreed that **Transformer Life** can be summarised as being the life of the insulation within the transformer since most failures are a result of insulation breakdown within the transformer. It is accepted however, that mechanical breakdown resulting from an electro failure occurs at the final stage. From this it is easy to conclude that it is desirable to maintain healthy insulation within electrical transformers. Terminal aging of the insulation by chemical reactions is very much accelerated by contaminants within the oil when it is ignored and allowed to buildup within the transformer. Oxidation occurs and once started has a compounding effect on the transformer insulation. Sludge in the transformer settles on the surfaces and creates hot spots which create and compound further deterioration and very quickly the cooling effect of the oil is effected which again aggravates the aging process of the insulation.