

## Moisture Tolerance and Asset Life Extension

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### Moisture Tolerance

MIDEL eN 1204 has a very high moisture tolerance. This means it can absorb far greater amounts of water than mineral oil and silicone liquid without compromising its dielectric properties. MIDEL eN 1204 can also consume water which may slow down cellulose ageing. In the case of mineral oil, there is a danger that this water will be released as condensation.

### Why Moisture Tolerance is Important in Transformers:

- ▶ Dielectric strength - reduces as moisture content increases
- ▶ Rate of paper ageing - increases with higher moisture content
- ▶ Condensation during cool down - risk of release of free water from mineral oil

### Dielectric Strength

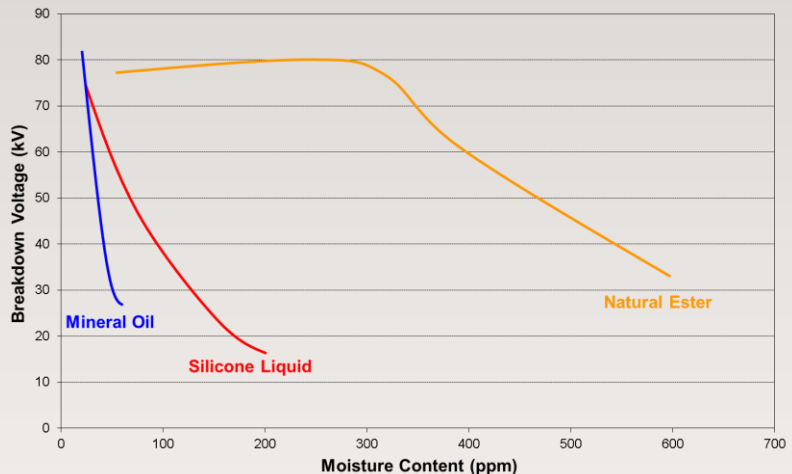
Figure 1 shows the breakdown voltage at ambient temperature of MIDEL eN 1204, mineral oil and silicone liquid with increasing moisture levels. It clearly illustrates that even a small amount of water in mineral oil and silicone liquid cause a rapid deterioration in breakdown voltage. In contrast, MIDEL eN 1204 maintains a high breakdown voltage of >75kV even when moisture levels exceed 300ppm.

### Rate of Paper Ageing

The rate of paper ageing is directly related to water content. Various studies have shown that the lifetime of paper reduces by as much as a factor of ten for each extra 1% of water content in the cellulose. As the cellulose ages it releases water, thus accelerating the ageing process. Therefore it is vital that cellulose is kept as dry as possible.

One study by reputable paper manufacturer Weidmann Electrical

Figure 1 – Breakdown voltage vs. moisture content at 20°C (IEC 60156 2.5mm)



Technology demonstrated that in sealed systems MIDEL eN 1204 can keep cellulose much drier than mineral oil, and hence significantly reduce the ageing rate. At a temperature of 150°C the tensile strength of pressboard immersed in mineral oil had dropped to less than 35% of its original value after four months, meaning it had reached end of life. Under the same conditions the pressboard immersed in MIDEL eN 1204 retained 57% of its original strength, and was still acceptable for further use.

### Condensation During Cool Down

With mineral oil there is a potential for water to be released when a transformer cools from operating temperature to ambient. This is due to the fact that mineral oil has a low moisture saturation limit which reduces as the temperature drops. MIDEL eN 1204 has a much higher saturation limit, which means that it is far more difficult to reach the saturation point.

For example if a transformer with mineral oil and a paper water content of 1.5% was running at 90°C the water content of

the mineral oil would be 65ppm. If the transformer then shut down the water would tend to stay in the mineral oil. At 20°C the saturation limit of mineral oil is 55ppm, so the mineral oil would be 118% saturated, releasing free water into the transformer. The breakdown voltage of the mineral oil will also be very low, increasing risk of failure when restarting.

Using the same example for MIDEL eN 1204 at 90°C the water content would be around 300ppm. The saturation limit for MIDEL eN 1204 at 20°C is 1100ppm, so even if all the water stays in the MIDEL eN 1204 it will only be 27% saturated. This means there would be no free water and still an excellent breakdown voltage.

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### Moisture Content Testing

The standards relating to moisture content for new fluids are shown in Table 1. New MIDEL eN 1204, as delivered, is manufactured to very high standards with a typical moisture content of 50ppm, reflecting the much greater ability of MIDEL eN 1204 to be moisture tolerant.

This has practical implications for the interpretation of moisture level analysis between MIDEL eN 1204 and mineral oil. Also, if moisture-monitoring equipment is integrated within a transformer, its tolerance settings should be adjusted accordingly.

### Moisture Removal

Should the moisture content rise above the maximum recommended in-service limit, the same methods and equipment that are used for removing moisture from mineral oil can also be used to remove moisture from MIDEL eN 1204. For example molecular sieves and vacuum filtration units.

For further advice please contact the MIDEL technical team:  
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Table 1 – Standards for Moisture Content

Standard	Moisture Content
IEEE C57.147 - New Natural Ester	max. 200ppm*
IEC 60296 - New Mineral Oil	max. 30ppm

\*sample from bulk tank