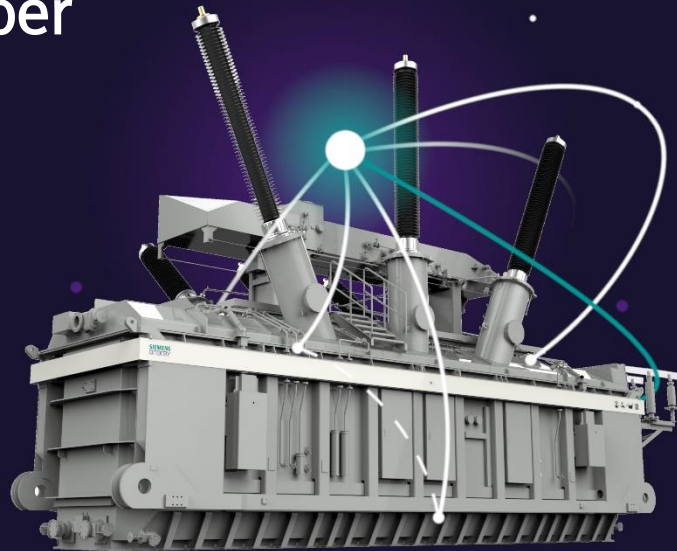


# The degree of polymerization value in new insulation paper

Customer information



[siemens-energy.com/transformers](https://www.siemens-energy.com/transformers)

## Degree of polymerization

The value of the degree of polymerization (DP) provides information about the mechanical condition of the winding insulation paper. The DP value is determined using the measurement of the average viscosity of the paper when is dissolved in a liquid. The method and correlation between the viscosity of this liquid and the DP value is defined in Standard IEC 60450 or similarly in ASTM D4243-99.

### Initial DP value

During aging of the insulation paper the DP value drops. The drying process of the windings and active part also contributes to a small amount of aging. Therefore, the idea was conceived to specify a high initial DP value so as to maximize the lifetime of the solid insulation. Insulation paper manufacturers claim DP values of new paper in the range of 1200 or higher. The influence of processing and temperature rise during testing amounts to a total DP drop of 200 or lower – only weak bonds of hemicelluloses are broken. Therefore, at the delivery stage of the transformer a guaranteed value close to a DP level of 1000 seems to be a realistic value at first glance.

### Internal investigations show a different view

In new condition before processing the average DP value of two different deliveries of winding copper with paper insulation shows average DP levels of 1091 (delivery 1) and 1055 (delivery 2) and a minimum value just below 1000 – as shown in Figure 1. The deviation of the results is the effect of measurement uncertainty and inhomogeneities of the insulating paper. Values as low as 900 were observed. Moreover the DP values from the suppliers can be based on local standards which are not indicated in the

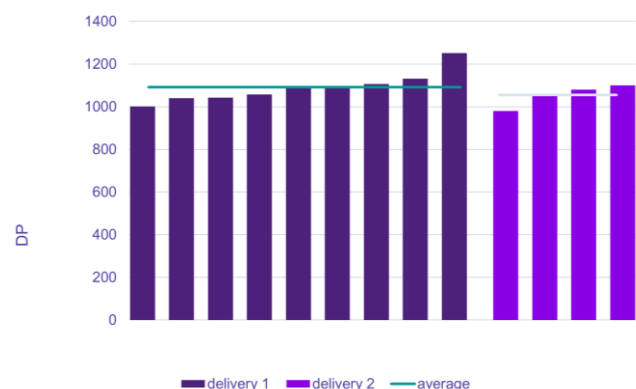


Figure 1 DP values of new paper measured according to IEC 60450

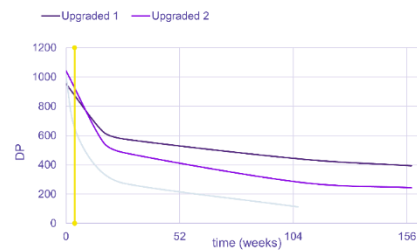
## Evaluation of the initial DP value

Figure 2 shows the DP value drop during the aging test in mineral oil at 120°C in the laboratory at Siemens Energy. All paper samples had previously passed winding and active part drying before the aging test commenced.

The thermally upgraded paper that showed better performance during aging has the lower initial DP value. However, it should be noted that nonthermally upgraded Kraft paper shows a higher aging rate.

Another aspect to be considered is the assessment of the initial DP value. In figure 2 the vertical line indicates an interval of 4 weeks, which reduces the average DP level of thermally upgraded paper from about 1000 to a level of 900.

This produces a DP difference of 100. If we assume an end-of-life DP level of 200 (208 weeks), the influence of the initial drop of 100 DP on the lifetime is relatively low: the lifetime reduction is smaller than 2%. The Kraft paper with its accelerated aging needs less than 1 week to achieve a DP drop of 100. Again, the lifetime reduction is less than 2% – based on a lifetime of 1 year (52 weeks) for DP 200. This example demonstrates the insignificant influence of the level of the initial DP value.



**Figure 2** DP values versus time at 120°C in oil of thermally upgraded paper and nonthermally upgraded Kraft paper

## Conclusion

- The initial DP value provides very limited information about the lifetime of the transformer insulation
- Specifications of DP thresholds require the consideration of big tolerances in single measured values. Single measured DP values of new paper without processing can go below 1000. Moderate processing of transformer active part cannot compensate for low DP values
- Thermally upgraded paper has a better aging performance than Kraft paper, even if the initial DP value is lower.

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