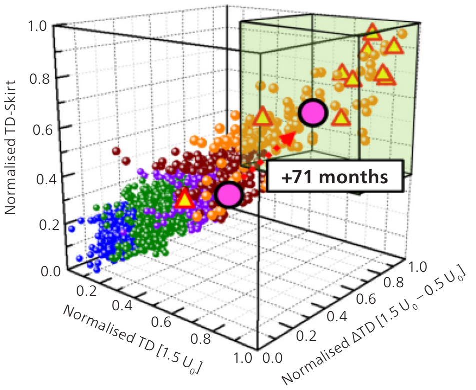
ensuring the flow

statex®

BAUR software for the statistical analysis of the cable life time developed by KEPCO

KOREA ELECTRIC POWER CORPORATION



3D illustration of the correlation between normalised evaluation parameters of dissipation factor measurements TD, ΔTD and TD-Skirt: The framed area top right in the illustration exhibits a high probability of error.

Experienced-based analysis of the cable condition and prognosis of the statistical remaining life time

- Analysis of the entire cable network condition based on different dissipation factor parameters
- LT Wizard – statistical tool for defining parameters for determining the remaining life time
- Innovative, patented evaluation algorithm for the statistical determination of the remaining life time of MV cables
- Validated by 45,000 dissipation factor measurements on 15,000 cable routes

The statex® analysis software is used for the detailed determination of the ageing condition, the speed of ageing and the statistical remaining life time of a cable route based on the dissipation factor diagnostics with VLF truesinus® voltage (Very Low Frequency).

In addition to the conventional evaluation parameters of IEEE 400.2 (SDTD, MTD and ΔTD) , the statex® also takes into account a new parameter - TD-Skirt - which illustrates the time stability of the dissipation factor (TD). This makes it possible to calculate the ageing index R and the speed of ageing V_R of the cable route. It is also possible to receive an exact recommendation for when a subsequent measurement should be performed, or when work is required on the cable route. The economical operating limit of the cable and a company-specific safety margin are also incorporated in the calculation, which determines the optimal point in time to replace the cable.

Taking into consideration individual company guidelines and the visualisation of complex correlations between the various analysis parameters in a 3D matrix, statex® offers a new, ground-breaking option for cost-effective, operationally safe asset management.

Features

- LT Wizard – a comprehensive statistical tool for evaluating measurement results and defining limit values for calculating the remaining life time of various cable types and lengths
- Information on the overall network condition enables targeted responses to critical cable conditions
- Determines the speed of ageing and the remaining life time of a cable based on the dissipation factor diagnostics with VLF truesinus® voltage
- 3D illustration of the correlation between normalised evaluation parameters TD median, ΔTD and TD-Skirt as a basis for determining the remaining life time of the cable
- Takes into consideration company-specific guidelines when determining a point in time for cable repairs (security of supply)
- New evaluation parameter TD-Skirt for estimating the remaining life time
- Ageing index R for the overall assessment of the dielectric losses, and voltage and time stability
- Calculates an “action required” date
- Median ranking – applied statistical method for excluding the influence of outlying measurement points
- BAUR diagnostics systems deliver measurement data to the required level of precision
- Simple maintenance of measurement and cable data in a central cable database

Objectives

- Optimal estimation of the remaining life time of the cable route
- Reduction in the failure rate
- Prevention of social costs

BAUR GmbH · Raiffeisenstraße 8, 6832 Sulz, Austria · T +43 (0)5522 4941-0 · F +43 (0)5522 4941-3 · headoffice@baur.at · www.baur.eu

RCC Electronics

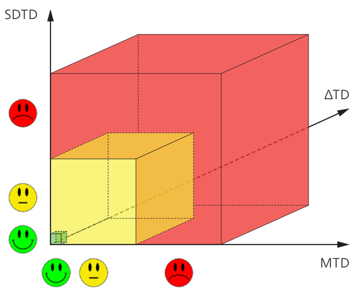
BAUR ensuring the flow

Determining the statistical remaining life time (principle)

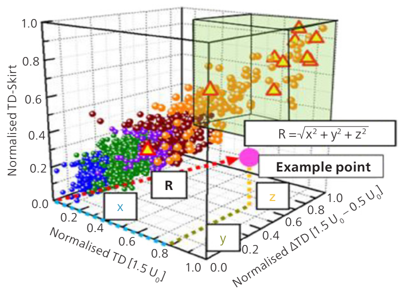
Based on the statistical evaluation of 45,000 units of measurement data on 15,000 cable routes (approx. 7,000 km), the patented algorithm of the statex® analysis software calculates a 3D ageing index R. This algorithm was developed and patented by the Korea Electric Power Corporation (KEPCO) in collaboration with Mokpo University (Korea).

Apart from the normalised evaluation of TD and ΔTD, the calculation of the 3D ageing index R also takes into consideration the new evaluation parameter, TD-Skirt. In addition to the parameters MTD, SDTD and ΔTD defined in IEEE 400.2, the calculation of the ageing index R enables a precise recommendation of when a subsequent measurement should take place, or when work is required on the cable route, e.g. in three year's time.

Evaluation according to IEEE 400.2*



Evaluation with statex®



Following on from the subsequent measurement and the recalculation of the ageing index R, and based on the index R of the two measurements, the speed of ageing and the anticipated remaining life time of the cable route are calculated. The difference between the economical operating limit and the specific safety margin of the utility company makes it possible to conclude when work will be required on the cable route.

Example – saving at KEPCO by using statex®

The evaluation of the TD measurement data of the 15,000 cable routes according to IEEE 400.2 determined that approx. 255 km of the cable in operation fell under the "Action required" (☹) category.

The evaluation of the same measurement data with statex® determined that approx. 55 km of the operational cable had a statistical remaining life time of <2 years. This means that is was not yet necessary to replace approx. 200 km of cable.

The KEPCO investigations showed that, compared with the evaluations performed according to the IEEE criteria, the evaluation of the measurements with statex® showed an average increase of 11 years in the statistical remaining life time of a cable.

Software evaluation options

- Display of the ageing index R for L1, L2, L3 of a cable route
- Historical course of the ageing index in the 3D illustration – compared to 45,000 measurement points of KEPCO
- Results:
  - Ageing index R
  - Speed of ageing V_R
  - Statistical remaining life time
  - Point in time of subsequent measurement
  - Calculated failure date
  - 3D status graph
  - TD-Skirt graph
- Warning notification of a calculated, potential failure
- Reminder function for new subsequent measurements
- Import of BAUR TD measurement data (BMF, MMF, IMF, MHT)

Company-specific setting options

- Ageing index R for various cable types
- Limit values for the ageing index R
- Safety buffer for cable repair or replacement prior to the calculated end of the duty period
- Definition of company evaluation criteria or criteria according to IEEE 400.2

* Evaluation criteria according to IEEE 400.2:

- 🙂 No action required
- 😐 Further study advised
- ☹ Action required

KEPCO KOREA ELECTRIC POWER CORPORATION

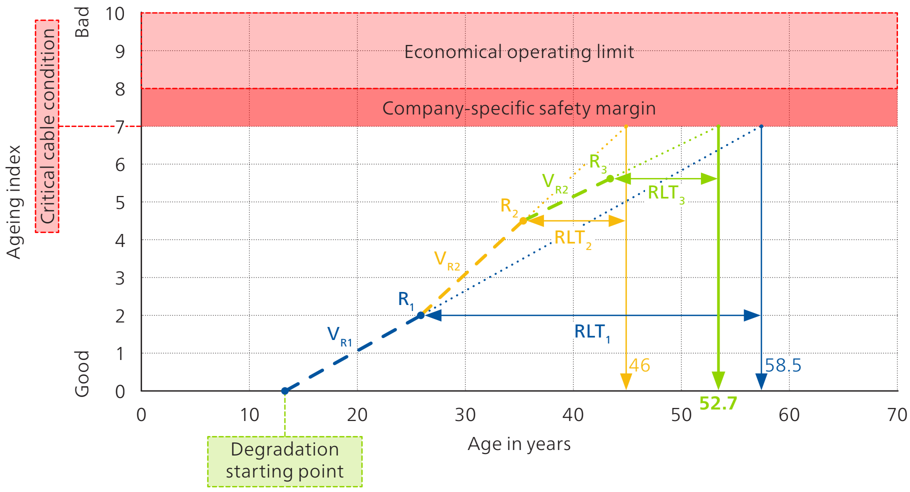
Software developed by KEPCO

RCC Electronics

ensuring the flow

Example – calculating the statistical remaining life time of a cable

In the following example, the statistical start of ageing (DSP – degradation starting point) is assumed to be at 13 years, and the critical cable condition (CP – critical point) a value of 7.0.



An initial dissipation factor measurement after a duty period (DP) of 26 years gives a value for the ageing index R_1 of the cable of 2.0. The speed of ageing V_{R1} can thus be calculated after the first measurement. With the speed of ageing, the statistical remaining life time (RLT) of the cable can be calculated after the first measurement.

$$V_{R1} = \frac{R_1}{DP_1 - DSP} = \frac{2.0}{26\text{ years} - 13\text{ years}} = 0.15\text{ years}^{-1} \qquad RLT_1 = \frac{CP - R_1}{VR_1} = \frac{7.0 - 2.0}{0.15\text{ years}^{-1}} = 32.5\text{ years}$$

From the statistical remaining life time, the anticipated operational age A_{CP1} of the cable when it reaches the critical cable condition can be deduced:

$$A_{CP1} = DP_1 + RLT_1 = 26\text{ years} + 32.5\text{ years} = 58.5\text{ years}$$

Measuring again after 10 years, i.e. when the cable has a duty period of 36 years, gives a second ageing index R_2 with the value 4.5. The speed of ageing V_{R2}, the statistical remaining life time RLT_2 and the anticipated operational age A_{CP2} of the cable when it reaches the critical cable condition can then be calculated as follows:

$$V_{R2} = \frac{R_2 - R_1}{DP_2 - DP_1} = \frac{4.5 - 2.0}{36\text{ years} - 26\text{ years}} = 0.25\text{ years}^{-1} \qquad RLT_2 = \frac{CP - R_2}{VR_2} = \frac{7.0 - 4.5}{0.25\text{ years}^{-1}} = 10\text{ years}$$

$$A_{CP2} = DP_2 + RLT_2 = 36\text{ years} + 10\text{ years} = 46\text{ years}$$

A second remeasurement after 8 years, i.e. when the cable has a duty period of 44 years, gives a third ageing index R_3 with the value 5.7. The speed of ageing V_{R3}, the statistical remaining life time RLT_3 and the anticipated operational age A_{CP3} of the cable when it reaches the critical cable condition can then be calculated as follows:

$$V_{R3} = \frac{R_3 - R_2}{DP_3 - DP_2} = \frac{5.7 - 4.5}{44\text{ years} - 36\text{ years}} = 0.15\text{ years}^{-1} \qquad RLT_3 = \frac{CP - R_3}{VR_3} = \frac{7.0 - 5.7}{0.15\text{ years}^{-1}} = 8.7\text{ years}$$

$$A_{CP3} = DP_3 + RLT_3 = 44\text{ years} + 8.7\text{ years} = 52.7\text{ years}$$

Taking into consideration the specific ageing of the cable, the evaluation of the two remeasurements give a potential duty period of the cable of approx. 52.7 years.

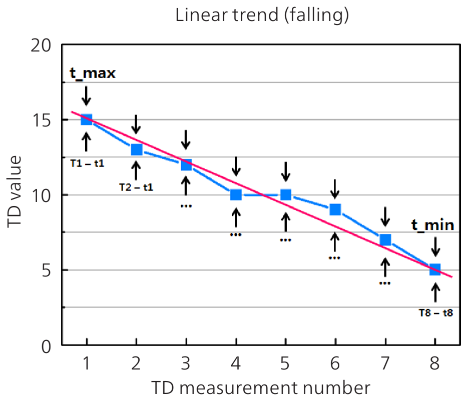
Software developed by KEPCO

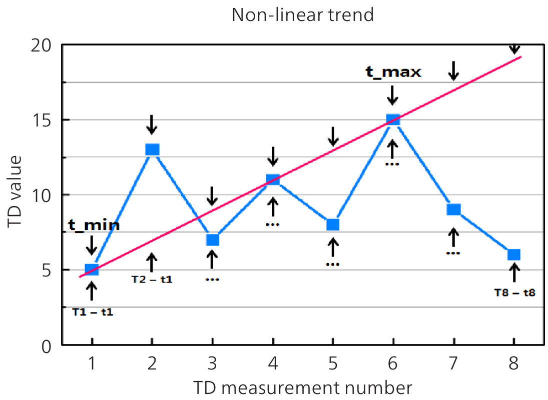
ensuring the flow

VLF TD criteria

New evaluation parameter TD-Skirt

In cables with insulation losses, there are precursors such as the constant increase or decrease or a fluctuation of TD values within a voltage step. The degree of change is known as TD-Skirt and describes the time stability of TD measurements. This is achieved by drawing a virtual line between the largest and smallest TD values of eight consecutive TD measurements. A linear (rising) trend in the measured values indicates a change in the dielectric losses of the cable insulation, while a falling or non-linear trend indicates e.g. moisture or electrical discharge in the cable terminations or joints.





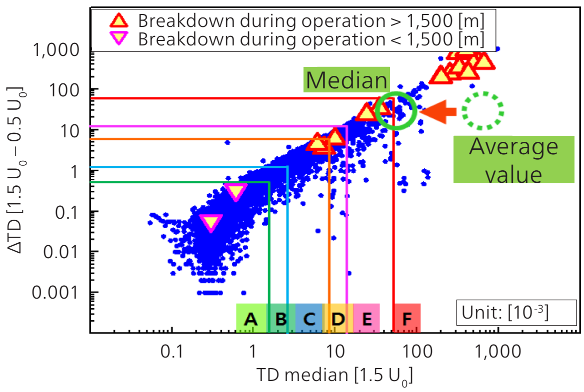
Ageing index R

The ageing index R is calculated from the normalised values TD, ΔTD and TD-Skirt, and provides information on the condition of the cable insulation of the cable under test at the time of the measurement. It is presented as a 3D vector.

$$R = \sqrt{TD^2_{norm} + \Delta TD^2_{norm} + TD\text{-}Skirt^2_{norm}}$$

TD median

The parameter TD median is the mean value over 8 TD values. Unlike MTD, with TD median, the irregular TD values are excluded by using median ranking in order to more accurately determine the condition of the cable. The following graphic illustrates the difference between the mean value and the TD median.



Median ranking

Median ranking is a statistical technique used for the more efficient analysis of the measured TD values and for counteracting the influence of outliers in a large dispersion of measured values.

KOREA ELECTRIC POWER CORPORATION

Software developed by KEPCO

Technical data

General	
User interface languages	English, German, Chinese (China), French, Portuguese, Russian, Spanish Other languages on request
Data import format	BMF, MMF, IMF, MHT
Report export format	PDF, PNG

System requirements	
Operating system	Windows 7 (or higher) Recommended: Windows 8 (or higher)
Memory	Min. 4 GB RAM Recommended: min. 8 GB RAM
SQL server	Microsoft SQL Server 2014
Microsoft .NET Framework	4.5 (or higher)

Available software licences

Licences	Functions		
	R calculation	Prediction of the remaining life time	LT Wizard
statex® core	✓	X	X
statex® pro (main licence)	✓	✓	✓
Additional workstation licence for statex® pro (in combination with statex® pro main licence only)	✓	✓ (calculation parameters are set centrally using the LT Wizard of the statex® pro main licence)	X
statex® pro package: 1 main licence + 2 additional licences	✓	✓	✓

RCC ELECTRONICS LTD.
Licensed Canadian Distributors
Tel: 905-669-6644
Toll-free: 1-800-668-6053
Fax: 905-669-6645
E-mail: sales@rcce.com
Website: www.rcce.com

Software developed by KEPCO

Contact:

BAUR GmbH (Head Office Austria)
T +43 (0)5522 4941-0
F +43 (0)5522 4941-3
headoffice@baur.at
www.baur.eu

BAUR Prüf- und Messtechnik GmbH
T +49 (0)2181 2979 0
F +49 (0)2181 2979 10
vertrieb@baur-germany.de
www.baur-germany.eu

BAUR France
T +33 (0) 170 701 045
F +33 (0) 172 718 485
info@baur-france.at
www.baur.eu/fr

Baur do Brasil Ltda.
T +55 11 297 25 272
atendimento@baurdobrasil.com.br
www.baurdobrasil.com.br

奥地利保尔公司上海代表处
电话 +86 (0)21 6133 1877
传真 +86 (0)21 6133 1886
shanghaioffice@baur.at
www.baur.eu/china

BAUR Test Equipment Ltd. (UK)
T +44 (0)20 8661 957
sales@baurtest.com
www.baurtest.com

BAUR Representative Office Hong Kong
T +852 2780 9029
F +852 2780 9039
office.hongkong@baur.at
www.baur.eu

BAUR representatives:
www.baur.eu/en/baur-worldwide

qualityaustria SYSTEM CERTIFIED ISO 9001:2015 No.00465/0