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ENERGY

HIGHLIGHT

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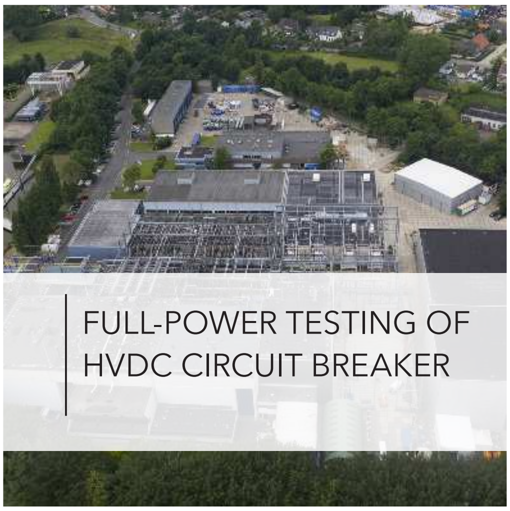

KEMA LABORATORIES CELEBRATES ITS 90TH ANNIVERSARY

FULL-POWER TESTING OF HVDC CIRCUIT BREAKER

FIRST TYPE TEST OF A 320 KV DC CABLE SYSTEM

SAFER, SMARTER, GREENER

Highlight is the quarterly newsletter of KEMA Laboratories.

KEMA Laboratories are part of DNV GL – Energy. Our expertise spans from proficiency in onshore and offshore wind power, solar, conventional generation, transmission and distribution, smart grids, and sustainable energy use to innovative involvement in the energy markets and regulations.

Our 2,300 energy experts support clients around the globe in delivering a safe, reliable, efficient, and sustainable energy supply.

We have over 80 years of experience in testing, inspections and certification – and the KEMA brand is renowned globally as the gold standard for quality. Our Testing, Inspections and Certification (TIC) activities are internationally recognised for their quality and integrity.

Our main product is the KEMA Type Test Certificate, which is issued if a component successfully passes an internationally recognised type test program in our laboratories. For our customers, the award of a KEMA Type Test Certificate is a respected indicator of the reliability and safety of their products. KEMA Laboratories are located in the Netherlands, USA, and the Czech Republic.

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Queen Máxima High-Power Laboratory

In Early October it already felt like the festive season had started, when KEMA celebrated its 90th birthday in Amsterdam, with a small conference with customers and other stakeholders. We officially opened the extension of our lab, renaming our short-circuit lab "Queen Máxima High-Power Laboratory" with full permission of her Majesty the Queen of the Netherlands. The opening means more power is available for testing, and with two additional machines, hopefully also more availability of the testing facilities to give our customers in future a more "royal" testing experience through enhanced efficiency and less waiting time.

In the meantime, business is going ahead and it seems that our industry is racing ahead to make sure that we collectively can tackle tomorrow's challenges. For example, the cable industry is making big investments to prepare new cable systems that can carry more energy either from point-to-point with higher voltage HVDC technology and on the other hand, we see big advances in traditional (sub-sea) AC systems. Novel HVDC Breaker technology, something we are now testing in our Arnhem lab could, of course, change the traditional boundaries between HVAC and HVDC applications

Over the last two years we have been meeting a lot of our customers at their facilities and offices, and we realize more than ever, that in most places it remains a challenge to keep the electricity flowing around the clock. We are happy to help and look forward to hearing from you!

Best regards,

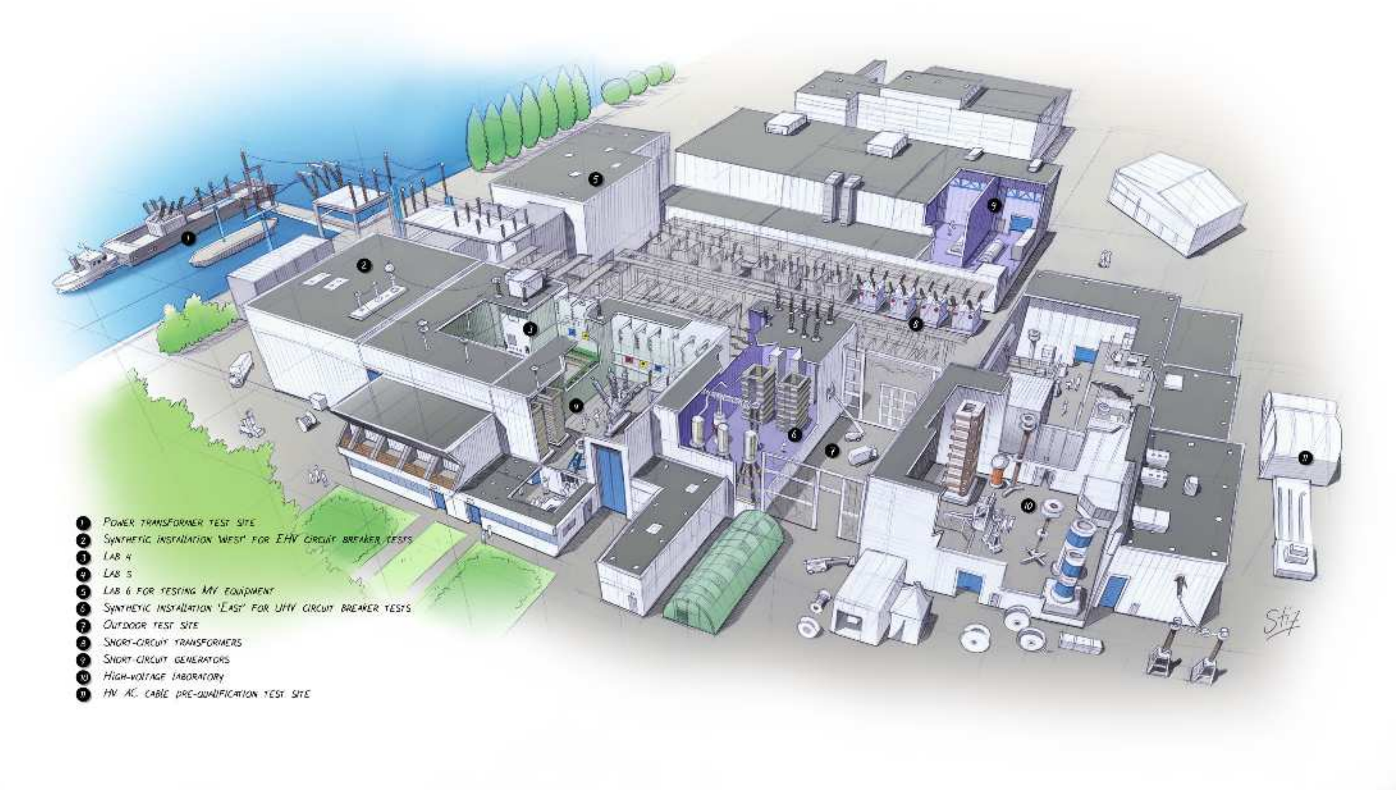
Jacob Fonteijne,

Executive Vice-President KEMA Laboratories

CONTENT

KEMA: A LIFE STORY

KEMA Laboratories celebrates its 90th anniversary this year. It was born as KEMA in 1927 to verify the safety and compliance of electrical components in the Netherlands and has since grown into a worldwide network of industry-leading testing facilities and a trusted partner to the global power industry.



As part of the celebrations, we are publishing a biography of KEMA's first 90 years: "Testing power: ninety years of high voltage and high power laboratories at KEMA". Drawing on contemporary articles and the recollections of KEMA employees past and present, it tells KEMA's story from its earliest days as an improvised installation in the annex of an old hotel right up to this year's opening of the world's first facility for testing ultra-high voltage super grid components.

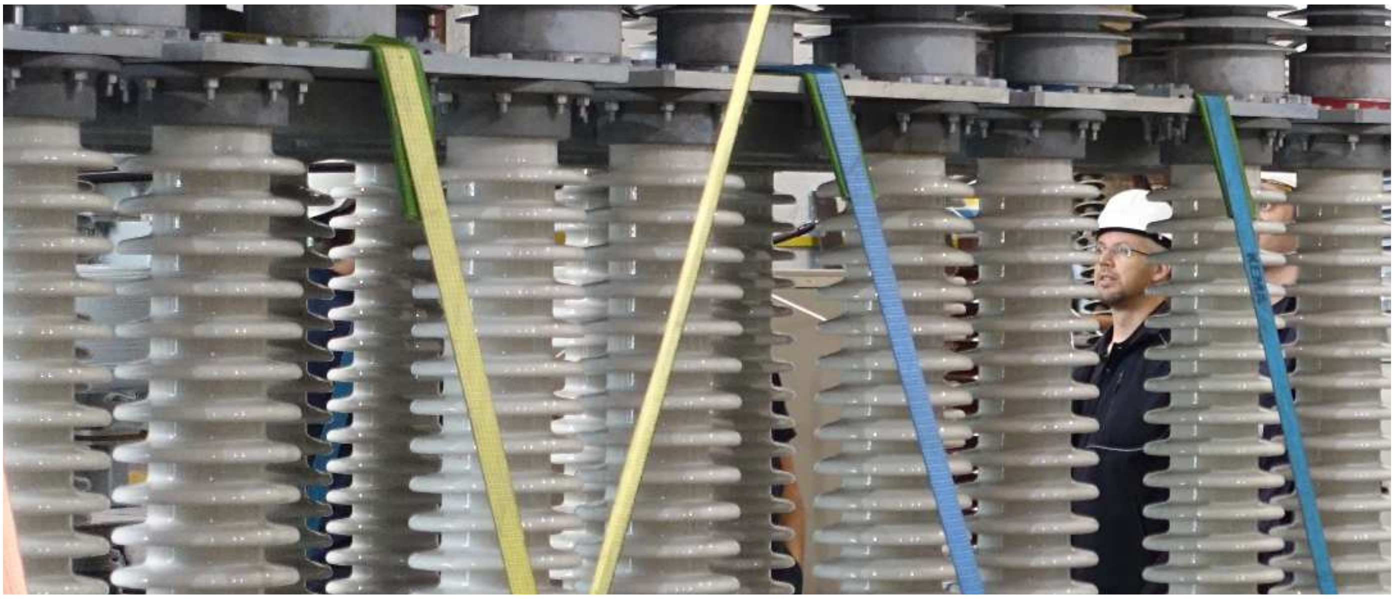
Along the way, the book uncovers the story behind the many innovations and highlights in KEMA's history, including:

- first short-circuit and high-voltage laboratories
- introduction of three-phase synthetic testing
- new facilities and techniques for testing automation, smart grid and HVDC components
- continuous investment to deliver the highest power and voltage levels in support of the industry's migration to ever-higher transmission voltages

"'Testing power' charts KEMA's rise from a small national research facility into a laboratory with a global impact and recognition. It gives a historical overview of the technology developments in the global transmission and distribution industry, and how KEMA has supported them at every stage through our own innovation," says Jacob Fonteijne, Executive Vice-President KEMA Laboratories.

If you would like to receive a free hard copy of the book, please contact us at: contact.kemalaboratories@dnvgl.com

FULL-POWER TESTING OF HVDC CIRCUIT BREAKER NOW REALIZED



In HVDC substations, a considerable number of switching components are installed. In the 2017 CIGRE Technical Brochure "Technical Requirements and Specifications of State-of-the-Art HVDC Switching Equipment", no less than 24 types of HVDC switchgear are identified, each with a different functionality.

They need to disconnect, earth, transfer, commutate, configure the transmission line topology etc., but basically do not need to interrupt the fault current. This is (yet) unnecessary, because almost all the world's HVDC projects are point-to-point links, that are de-energized by the converter stations when a fault occurs. In addition DC current interruption is technically very challenging because it is completely different from AC, since DC current does not have a zero crossing.

At present however, the concept of DC grids harvesting renewable energy in large volumes is imminent in several parts in the world and actually being realized in China. Such HVDC grids need a way to isolate faulty sections, and HVDC circuit breakers offer this possibility.
The topic HVDC fault interruption has become a key product development issue with all the major manufacturers and is heavily discussed in CIGRE and IEEE. Several solutions and prototypes have been proposed but no equipment has been installed in service yet.

In the framework of the EU Horizon 2020 R&D program PROMOTioN (https://www.promotion-offshore.net/), KEMA Laboratories are committed to demonstrate testing of HVDC circuit breakers.

Our idea is rather straightforward: by running the lab's AC short-circuit generators in a low-frequency mode (e.g. 16.7 Hz, which is a power frequency in European traction grids) there is a window of opportunity to exploit the DC-like nature of the AC power around the crest of the AC sine wave provided the interruption process of the HVDC breakers is short enough to fit into this DC-like window.

An unconventional requirement of a HVDC breaker is its capability to absorb the energy in the DC grid, after the current has been interrupted locally either with power electronics, with very fast mechanical breakers or a combination of these. In all technologies of the HVDC breaker, the final suppression of the fault current to zero in the HVDC link, is achieved by applying a temporary overvoltage opposite to the converter station supply. This counter voltage is created by metal oxide surge arresters (MOSA). These need to conduct, during an unusually long period, the large declining current while at the same time maintaining the high overvoltage. The energy generated in this process heats up the MOSA and this needs to be reproduced by a test circuit, and this is where generators kick-in naturally.

The key issue is that the supply voltage must be "up" long enough to include the energy absorption process from beginning to end. Although in R&D tests of HVDC breakers very large capacitors are used to simulate this process, the energy storage of even the biggest practical capacitor bank is not big enough to match the energy stored in rotating mass of generators. Hence , such tests are limited to demonstrating local current zero creation only, not the actual interruption of the DC current with all its thermal stresses from the grid energy, dumped into the breaker. The use of AC generators as power supply source in a complete, one-stop testing of HVDC circuit breakers is elaborated in detail in reference 1.

However, since the concept of HVDC grids is only in its infant stage, and they actually do not exist yet, how can we know what the stresses on its future components are? Whereas for AC switchgear well-defined and agreed standards and test requirements exist, this is not the case for HVDC switchgear, let alone HVDC circuit breakers. KEMA Laboratories, also in the frame work of PROMOTioN, has conducted system studies of future HVDC grid scenarios, as defined by CIGRE, and also in simplified scenarios in order to define trends and unfavorable conditions of faults. As a result, fault characteristics that form the basis of HVDC breaker testing are derived. The actual stresses on the equipment will be project dependent. This study is summarized in reference 2.

The studies have culminated in actual power testing of a 70 kV HVDC circuit breaker, including current zero creation and energy absorption. The design is based on current zero creation of 16 kA fault current by counter current injection into an ultra-fast high-voltage vacuum interrupter. An oscillogram of this test at full fault current is given below, showing the relevant stages of interruption. Here, a prospective current that rises up to 33.5 kA is added for comparison purpose. In the next stage of the HVDC test development project, other technologies of HVDC circuit breakers will be tested, as well as devices for higher system voltages.

Also in IEC, initiatives are starting in TC 115 and 17A to address testing and standardization of DC switchgear. The working group in TC 17A, dedicated to HVDC switchgear will be starting end of 2017.

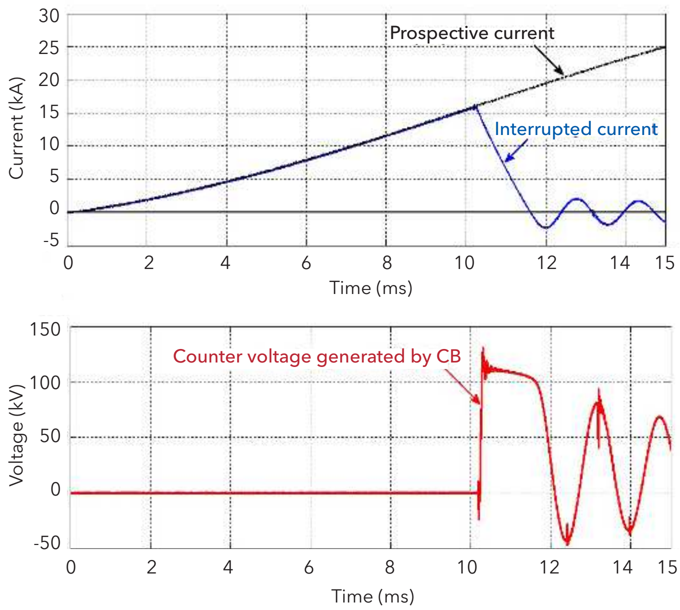


Figure 1 - Test results of active current injection HVDC circuit breaker at KEMA Laboratories

1. N.A. Belda, R.P.P. Smeets, "Test Circuits for HVDC Circuit Breakers, IEEE Trans. on Pow. Del., Vol. 32, no.1, pp. 285-293", 2017
2. N.A. Belda, C.A. Plet, R.P.P. Smeets, "Analysis of Faults in Multi-Terminal HVDC Grid for Definition of Test Requirements of HVDC Circuit Breakers", IEEE Trans. on Pow. Del., accepted for publication, 2017

FIRST TYPE TEST OF A 320 KV DC CABLE SYSTEM

Two unique test requirements in testing a HVDC cable system compared to that of a HVAC cable system exist: a specified maximum temperature drop across the insulation of a cable and a superimposed impulse withstand test.

The temperature difference of insulation (excluding the semiconducting screens) is provided by the cable manufacturer depending on the insulating material (e.g. XLPE: cross-linked polyethylene) and the cable design. This temperature difference needs to be maintained within a specified range during the steady state period of a thermal load cycle. In practice, it is not possible to measure temperature drop across the insulation directly.

In order to maintain a constant surface temperature of the cable, needed to guarantee a specified temperature difference of insulation , a practical method has been applied by controlling the load current through the conductor and maintaining constant ambient temperature or applying external thermal insulation material.

A superimposed impulse withstand test is essential for a HVDC cable system to be qualified for two different HVDC converter technologies, Line Commutated Converter (LCC) and Voltage Source Converter (VSC). A laboratory test set-up is designed for switching/lightning impulse (SI/LI) voltage superimposed on the DC voltage. A wide-band voltage divider is applied to measure the combined stresses for the HVDC cable system.

A proper test setup using a sphere gap has been developed for the application of SI/LI superimposed on a DC voltage. The correct gap adjustment is essential for unipolar stress, otherwise under certain circumstances, high-frequency oscillations might occur.

Further experimental work will focus on a method of controlling cable sheath temperature, and developing a new three-channel software with extended data acquisition time (up to recovery time of DC voltage). Furthermore, a capacitor is an alternative of a sphere gap to realize the superimposed withstand test.

Introducing Yansong Luo

Country Manager, KEMA Laboratories, Greater China

Yansong Luo is the country manager for KEMA Laboratories, Greater China.
Since 1985, Mr. Luo has started his career in the Power Electrical Transmission & Distribution sector, now he has over 30 years' experience in this field. From 2004 Yansong Luo is responsible for marketing, sales and technical support of Greater China and ASEAN countries.

Introducing Zhang Yu Jim

Sales and Business Development Representative, KEMA Laboratories, Greater China

Jim started his career in 2009, and held various sales roles in electrical component manufacturers and independent certification body in Grid T&D sector. He has a degree in Electrical Engineering. From 2016, Jim is working for KEMA Laboratories as a Sales and Business Development Representative based in Shanghai, China. He is dedicated to develop business opportunities in Greater China and ASEAN countries along with our China team.

EVENTS

INMR World Congress
5 - 8 November 2017
Sitges - Barcelona, Spain

EP China
20 - 22 November 2017
Shanghai New International Expo Center
Shanghai, China

Jicable HVDC'17
20 - 22 November 2017
Dunkerque, France

Australian Utility Week
29 - 30 November 2017
Melbourne Convention & Exhibition Centre
Australia

World Future Energy Summit (WFES) 2017
15 - 18 January 2018
Abu Dhabi National Convention Centre (ADNEC)
Abu Dhabi, UAE

Distributech Conference and Exhibition
23 - 25 January 2018
San Antonio, TS - USA

Middle East Electricity
6 - 8 March 2018
Dubai World Trade Centre, UAE

Elecrama 2018
10 - 14 March 2018
Greater Noida, India

TESTING ACTIVITIES

SHANGDONG TAIKAI HIGH VOLTAGE SWITCHGEAR CO., LTD. SUCCESSFULLY TESTED 550 KV CIRCUIT-BREAKER

Shangdong Taikai High Voltage Switchgear Co., Ltd. has successfully tested their LW-550(P)/Y5000-63, Live Tank circuit-breaker. The circuit-breaker is rated 550 kV - 63 kA – 50 Hz. KEMA Laboratories will issue a Certificate for Short-circuit and Switching Performance according to IEC 62271-100.

HVDC CIRCUIT-BREAKER TEST CIRCUIT SUCCESSFULLY APPLIED WITH MITSUBISHI ELECTRIC EUROPE HVDC BREAKER PROTOTYPE

In the framework of the EU project "PROMOTioN", cooperation between Mitsubishi Electric Europe and KEMA Laboratories Arnhem resulted in the demonstration of full-power DC fault clearing testing with a prototype mechanical HVDC circuit breaker using active current injection. During the demonstration, bidirectional test currents of DC 2 kA, 6 kA, 10 kA, interrupting current of 16 kA and test dissipating energy duties ranging from 1 MJ to 3.6 MJ were successfully delivered to and interrupted by a prototype unit of a mechanical DC circuit breaker with active current injection. The test object, supplied by Mitsubishi Electric, has the interrupting capability of 16 kA for corresponding breaker operation time of 8 ms. The MOSA restriction voltage for this mechanical DC circuit breaker is set as 1.5 times of 80 kV. The tests have been performed at generator frequencies of 16 2/3 Hz and 30 Hz. As part of the test method, a high-speed by-pass and isolation circuit to protect the test object in case of failure has been successfully demonstrated.

PT KMI WIRE AND CABLE TBK SUCCESSFULLY PASSED FULL TYPE TEST ON A 150 KV 2000 MM² POWER CABLE

PT KMI Wire and Cable Tbk, one of the biggest cable manufacturers in Indonesia, has successfully passed the full type test on a 150 kV 2000 mm² power cable. The test was performed according to IEC 60840 (2011) at KEMA Laboratories Arnhem. The test was witnessed by PT PLN (Persero), the Indonesia state owned electricity company. Director Global Sales KEMA Laboratories, Mr Gerd Enoch, congratulates the Commercial Director, Mr Dede Suhendra, with obtaining the KEMA Type Test Certificate.

SUCCESSFUL COMPLETION OF EXTENDED TYPE TEST PROGRAM ON A 320 KV HVDC CABLE SYSTEM

An extended type test program, in accordance with a client's specification, on a 320 kV HVDC cable system, manufactured by General Cable France, has been successfully completed. The test program surpasses the test program of Cigré TB 496. The photograph shows the test set-up for the superimposed voltage tests.

SHANGDONG TAIKAI HIGH VOLTAGE SWITCHGEAR CO., LTD. SUCCESSFULLY TESTED 38 KV CIRCUIT-BREAKER

Shangdong Taikai High Voltage Switchgear Co., Ltd., from Tai'an China, has successfully fulfilled the tests for a KEMA type test certificate of short-circuit performance on a 38 kV-2000 A-31,5 kA-60 Hz three-phase air-insulated outdoor vacuum circuit-breaker. The tests were performed according to IEEE C37.09 at KEMA Laboratories Arnhem.