WEIDMANN
ELECTRICAL TECHNOLOGY

WEIDMANN DESIGNS AND MANUFACTURES INSULATION SYSTEM FOR ULTRA-HIGH VOLTAGE (UHV) TEST REACTOR

In 2005 **Phenix Technologies**, the leading manufacturer of high voltage test systems, received a request from **CGIT Systems Inc.** to develop and supply a **1000 kV AC rated voltage UHV test system** for testing of high voltage **Compressed SF_6 Gas Insulated Transmission Bus Systems** (CGIT bus). CGIT bus systems are used in new Gas Insulated Substations (GIS), as well as for a wide range of other applications including substation optimization, below grade transmission, tunnel and vertical shafts, line crossing, elevated installations, and retrofit. These systems are made in fully assembled and factory tested straight modulus of up to 18 meters (59 feet) in length.

The major challenge in designing and manufacturing electrical equipment for Extra-High Voltage (EHV) and UHV transmission systems is to develop adequate insulation systems that guarantee reliable long-term operation of the equipment. Because the quality of insulation systems is validated with the high voltage tests, it is understandable that there is an increasing demand in EHV and UHV test systems capable of testing substation and transmission electrical equipment of such high voltage levels.

After analysis of available options, Phenix Technologies decided to design and manufacture an **AC Resonant Test System With Variable Inductance UHV Tank Type Reactor**. This solution provided significant advantages for this particular application. Resonant test system can be utilized for testing any object with a predominantly capacitive resistance (high AC voltage withstand test, partial discharge test, etc.).

The variable inductance **Tank Type Reactor** is a key element of this test system. The insulation system of the reactor provides the solution for the high voltage aspects of the test system, while its variable inductance is used for tuning up the resonance mode of the system.

Facing the significant project challenges as for the design of the UHV insulation system for the test reactor, Phenix Technologies asked Weidmann to partner and to lead the reactor high voltage insulation part of the project.

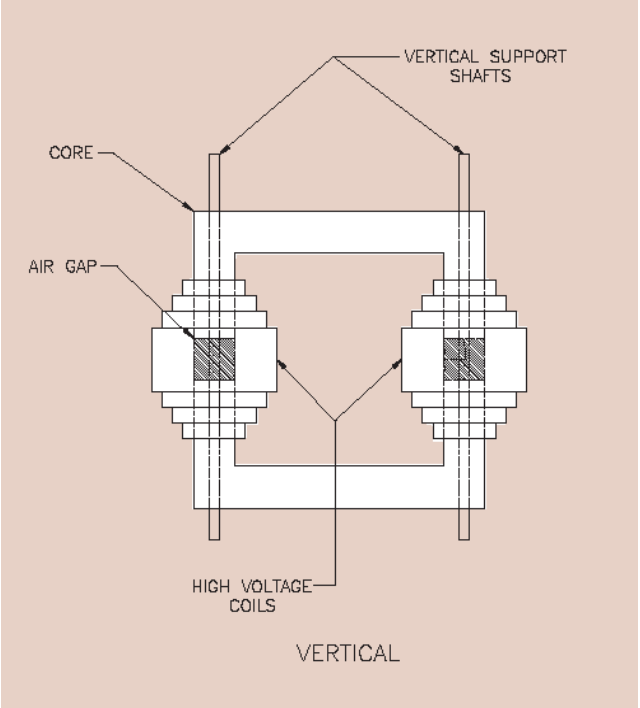
Weidmann Electrical Technology is a worldwide leader in the design and manufacture of high voltage insulation systems for a variety of applications. Weidmann continues to be closely involved in numerous EHV and UHV systems projects around the globe. Several recent examples of such projects are shown here.

Project	Year	Customer	Voltage
Sylmar, USA, Repair	1999	ABB	DC 500 kV
East-South India	2001	Siemens, Germany	DC 500 kV
Shellform Insulation Design	2001	Hyosung, S. Korea	AC 765 kV
China	2003	Shenyang, China	AC 750 kV
Basslink, Tasmania	2004	Siemens, Germany	DC 500 kV
Manitoba Hydro, Canada	2005	Areva, France	DC 500 kV
Qian Xi, China	2005	Hengyang, China	AC 500 kV
China	2005	Boading, China	AC 800 kV
China	2007	Xian, China	AC 1000 kV

THE REACTOR INSULATION SYSTEM DESIGN

There were several specific aspects of the reactor design that affected the insulation system design and resulted in very demanding dielectric analysis in order to optimize the insulation system:

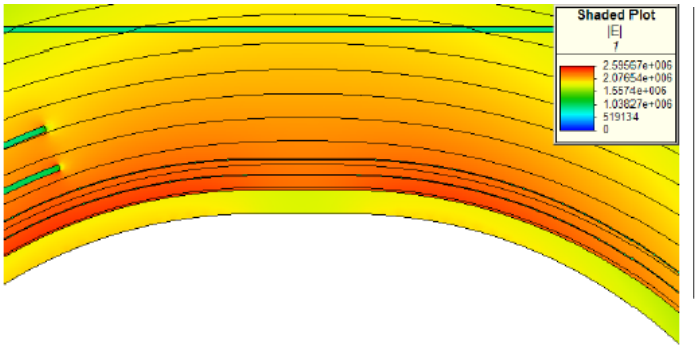
- Limited test field space (footprint and height) at the end user site required designing a compact insulation system in the relatively small volume of the reactor,
- Parts of the reactor (coils, tank) had irregular configuration compared to the “traditional” power transformers and reactors,
- Active part of the reactor was shielded (screened) from the metal parts of the construction with the several screens,
- Core of the reactor was movable, several dielectric analyses were required for the different positions of the core in this case.

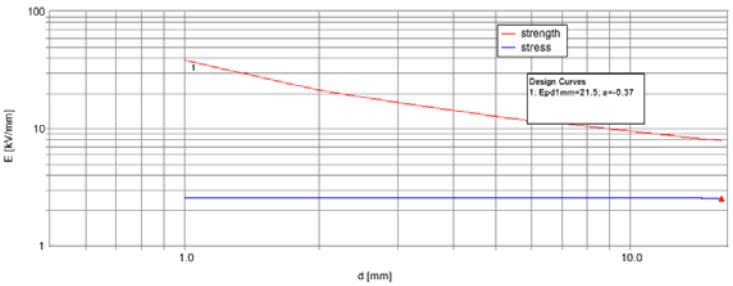


“A high voltage project of this magnitude presented a clear challenge to both Weidmann and Phenix Technologies,” states Tom Prevost, Weidmann Manager of Technical Services at the time of the project. “There simply were no similar projects that had been verified by tests or long term operation. However, once we identified the possible hurdles, we recognized that this project was definitely within Weidmann’s field of expertise.”

Weidmann employed its very effective electric **Field Element Analysis (FEA) software**, which allowed conducting about a hundred involved field calculations and analyses in a reasonable time.

The most important aspect of the dielectric analysis is to apply the reliable (validated) criteria. In this project Weidmann used the **set of the design criteria** that has been internally developed over years of intensive research, extensive design practice, and long-term real life verification. Once again, Weidmann’s insulation design proved to be both optimal and safe for the UHV applications.





Comparison of max. averaged field and oil curves in function of the respective gap length

Test Voltage : 1100.kV Percent Margin : 67

Because of the specific geometry of the elements of the reactor and space limitations, the configuration of the insulation components was carefully designed to reflect and optimize the electric field distribution, and to provide necessary safety margins of the insulation regions.

As the result of this work, the major oil-barrier insulation system of the reactor, as well as the shield insulation for oil-SF_6 type bushing, was designed, optimized, and coordinated with the Phenix Technologies’ reactor design.

MANUFACTURING THE REACTOR INSULATION SYSTEM

As the next step of the project, Weidmann developed drawings for all insulation components of the reactor insulation system including winding forms, barriers, supporting and spacing components, angle rings, caps, and screen insulation.

Because of the specific aspects of the reactor design, the configuration of the insulation system required use of a special insulation board molding process. The components are formed from the transformerboard on special forming molds and then dried out in the oven to form the parts with specified characteristics. The design of this test reactor utilized about 50 different molded components requiring 19 different tools for their production. Because of the project time constraints, Phenix Technologies proactively manufactured and delivered to Weidmann many of these tools. All molded insulation assemblies were preassembled at Weidmann's facility to ensure complete conformance of the components.

Tracy Marco, Team Leader of the Weidmann Molding Department stated, "The molding work for the 1000 kV test reactor turned out to be, probably, the largest single-order job our department has ever accomplished".

Because of the delicate nature of these wet molded components, special precautions had to be applied to the packaging and shipping of the complete insulation kit to Phenix Technologies.

THE REACTOR ASSEMBLY AND TEST

Weidmann supported Phenix Technologies during the assembly of the insulation system with a visit to their plant. Elevated attention was given to the reactor insulation system dry-out and oil processing because of the Ultra-High Voltage and the high amount of insulation per volume unit of the reactor.

Several iterations of processing allowed Phenix Technologies to reach the acceptable level of the controlled parameters and to submit the test reactor and the whole resonant test system to the acceptance test at Phenix Technologies' test field.

The acceptance test of the system was defined as a one-hour long, partial discharge-free test at 1000 kV, 60 Hz AC voltage. The important aspect of the dielectric reliability of the reactor is the ability to withstand numerous transient processes that occur when an SF_6 test object (bus) has a dielectric failure (flashover) during the test. Significant efforts were invested by CGIT Systems Inc. and Phenix Technologies to design the proper protection system to control these transient processes.

As a preparation for the acceptance test, several two-minute tests at 1100 kV, 60 Hz AC voltage were performed. Then, the test system with the reactor passed all necessary high voltage tests at the Phenix Technologies site, as well as at the end user test field.

RESULTS

This is the first 1000 kV rated voltage variable inductance UHV test reactor. It was designed and tested, and the resonant test system was commissioned to the end user.

Aleksandr Levin, Weidmann Technical Services Engineer and Project Leader stated, "To the best of our knowledge, **the rated AC voltage of 1000 kV is the highest voltage that has been implemented for this type of equipment for the first time worldwide."**

The accomplishment of this project was the result of the good team work between Weidmann and Phenix Technologies. Chief Engineer Jeffrey Britton and Mechanical Designer Jay Ross of Phenix Technologies deserve special credit for the success.

WEIDMANN CAPABILITY - WEIDMANN SOLUTIONS

This project clearly demonstrates Weidmann's capabilities:

- Designing and manufacturing EHV and UHV insulation systems,
- Employing a thorough understanding of the high-voltage engineering,
- Using up-to-date design techniques,
- Utilizing unique and versatile production capabilities

The International Energy Outlook 2006 projections indicate continued growth in world energy use, despite increasing world oil prices. This trend is driven by the world economy annual growth of 3.8 percent over the projected 2003 to 2030 period. Total world consumption of marketed energy is projected to have a 71 percent increase over the same period.

This increasing demand represents a significant challenge for the energy generation, transmission and distribution structures, especially in the emerging new economical powerhouses of China and India, where the energy consumption is projected to nearly triple over this period.

To transfer large amounts of electrical power over long distances economically and reliably, more and more countries are either already developing or studying the application of Extra-High Voltage (EHV) and Ultra-High Voltage (UHV) transmission systems (usually, the nominal voltages of 1000 kV AC and 800 kV DC are understood to be UHV).

The quality of the insulation materials and components plays a crucial role in the feasibility and reliability of such systems. Weidmann has the capability and expertise necessary to design and build these insulation systems and provide the required solution.

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