SIEMENS energy

STARON bushings

The unique solution for renewable energy applications

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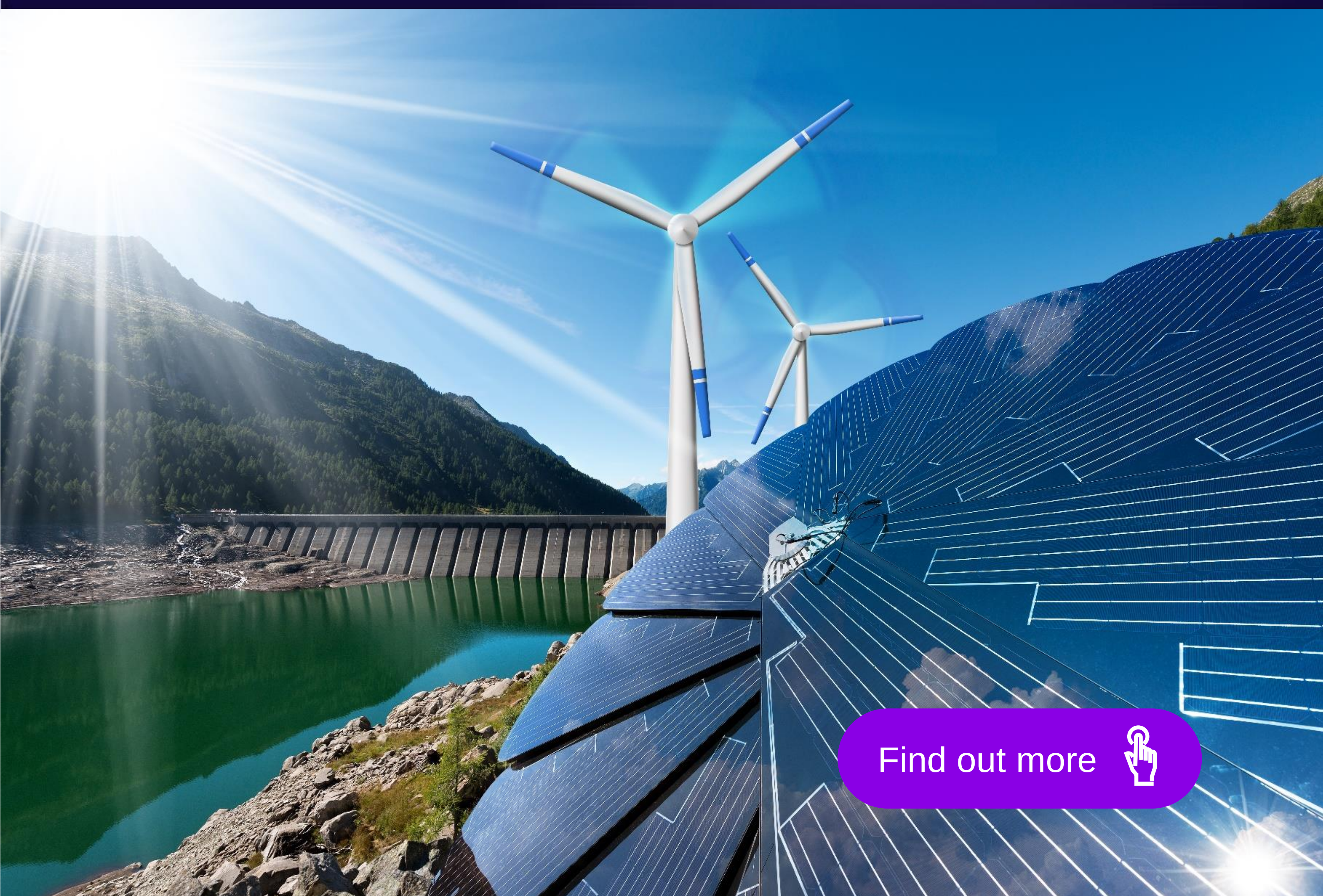


Introduction

STARON is the enhanced generation of Siemens Energy's OIP condenser bushings suitable for T&D applications and specifically "**qualified for renewable power generation applications**" with voltage ranges from 25 kV through 500 kV.

The traditional design of oil-impregnated transformer bushings incorporates a nitrogen cushion to compensate for the volume changes of the oil during operation due to temperature fluctuations. As such, there is a constant exchange of nitrogen between the gas cushion and the oil depending on temperature and pressure conditions inside the bushing. If an OIP bushing operating at near maximum temperature undergoes a rapid drop in temperature, there is a risk that nitrogen will reach oversaturation in the oil and form gas bubbles inside the insulation of the bushing core.

The STARON Solution

With the increased growth of renewable energy applications, new challenges appear for the design of suitable transformer bushings as gas bubbles may appear in the oil of transformer bushings when subjected to high cyclic loads. The presence of such bubbles leads to partial discharges within section of the electrically stressed insulation and eventual bushing failure. Siemens Energy has developed the STARON bushings to address this type of uses by applying a design principle that prevents the formation of gas bubbles by keeping the oil-to-gas volume ratios and internal bushing pressure at pre-determined values even under the highest expected operating temperatures and cyclic loads.

"Qualified for renewable power generation applications"

The design principle based on optimal gas-to-oil volume ratios is validated by a proprietary test where partial discharges are measured at high voltage and under rapid cooling (PD_RC*[1]) that simulate cyclic loads conditions found in renewable energy applications such as solar and wind farms and conventional peaker plants fueled by natural gas.

Key Benefits

Performance

- Qualified for **cyclic thermal loading**, **solar and wind farm applications**
- **No venting of bushings** before transformer testing **allowing faster process time for OEMs**
- **High electrical and thermal margins**
- **Partial discharge free** under rapid cooling conditions
- **High seismic qualification** performed through shake table test
- Qualified for optional **ambient temperature down to -60°C**
- **Customized solutions** to answer customers specific requirements

Design

- Prevent the formation of gas bubbles
- Draw lead adapters allow **replacement** of old draw lead bushings without modification of the existing stud/bolt & cable
- **Anti-syphon system** allows horizontal transportation, storage with no resting time for operation
- Air side insulator: **porcelain or composite insulator** are cemented into the flange for increased cantilever withstand capability
- Oil side epoxy insulator providing **high impact resistance** and **reduced size**
- Embedded end shield in the epoxy eliminates external shielding in draw lead applications up to 230 kV and provides capability to **reduce distance to grounded parts**

Logistic

- **Local bushing inventory** maintained on stock for **quick delivery** requirement
- Product already homologated by US local utilities

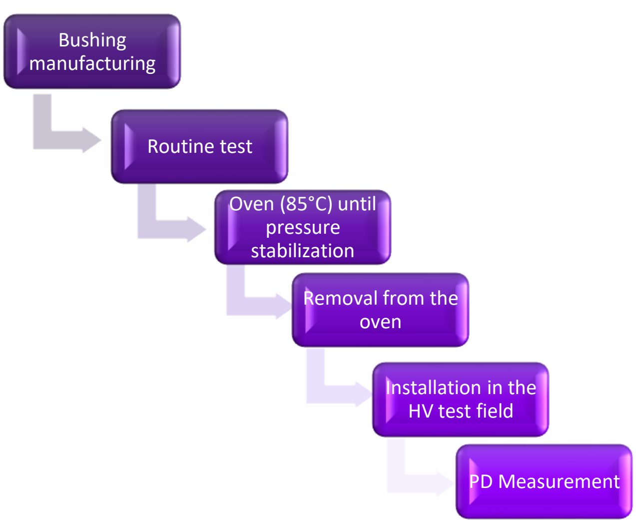
1 PD_RC* Test: Partial discharge test under rapid cooling.

PD_RC* Test

Tested bushings are installed in an oven and heated for several weeks at a temperature representative of operating conditions. Nitrogen migrates from the gas cushion to the oil until reaching saturation, leading to a pressure decrease inside the bushing. The constant monitoring of bushing pressure enables to identify the stabilization of nitrogen migration. When the bushing has reached a stabilized test, it is taken out of the oven for rapid cooling and installed in the high voltage test field. Partial Discharge measurements are performed for 24 hours, at voltage levels corresponding to transformer tests (IEEE Std C57.12.00 Table 5). Partial Discharge activity is indicative of the creation of bubbles in the insulation of the bushing.

Nominal System Voltage (kV)	Enhanced 7200 cycles	One hour
25	29	24
34,5	41	32
46	55	42
69	81	63
115	120	105
138	145	125
161	170	145
230	240	210
345	360	315
500	520	460

Table 1 – Voltage levels for Partial Discharge Measurements



Test Results

After more than 3 months of heating inside the oven, STARON bushings were subjected to rapid cooling and high voltage tests. None of the prototypes showed any Partial Discharge activity during the test. The power factor and capacitance of the bushings remained stable before and after the test.

Venting the bushing to atmospheric pressure during transformer Factory Acceptance Test is a practice often used by transformer manufacturers when nitrogen bubbling leads to electrical failure during the test. This practice can compromise the integrity of the bushing and is only a quick-fix to pass the tests. It does not remove the risk of gas bubbles in operation for renewable applications.

The successful PD_RC*[1] tests performed on STARON bushings up to 230 kV demonstrated the robust performance capabilities of STARON design for cyclic applications such as renewable energies, and removed the need to vent and break the sealing of the bushing to pass Factory Acceptance Test.

1 PD_RC* Test: Partial discharge test under rapid cooling.

Published by

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For the U.S. published by

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