TECHNICAL REPORT

TUG
Graz University of Technology

Auftraggeber: **Customer:**	Clean Tunnel Air International AS Hårstadreina 13 N-7092 Tiller Norway
Gegenstand: **Object:**	EP-cell for traffic tunnel
Datum und Zeichen des Auftrages: **Date and Signation of Order:**	Mr. Hans Anderl E-mail of September 6th, 2006
Untersuchungen: **Investigations:**	Field calculation, voltage tests
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1 General

During August/September 2006 a first series of high voltage tests on a new designed EP-cell for cleaning exhaust air of traffic tunnels for Clean Tunnel Air International AS have been carried out at Graz University of Technology, Test Institution of High Voltage Engineering Graz Ltd (see Technical Interim Report VAG 06157, Sept. 11th, 2006).

The second series of the tests, described as followed, dealt with the calculation of the electric field strength of the new designed insulator used for the ionizer, which had been developed and improved in cooperation with Graz University of Technology. Furthermore the breakdown voltage test of the ionizer and the estimation of the long-time behaviour of the new designed insulator have been carried out.

2. Investigations and tests on the new designed insulator

2.1 Description of the insulator

Fig. 1a shows the detailed view of the new designed insulator. It consists of an epoxy glass laminated disk combined with a glued insulating tube of the same material. The type of glue is also the same used for the manufacturing process of this insulating material. Fig. 1b shows the detailed view of the built-in insulator and fig. 1c shows the test arrangement with the view into the ionizer zone where one can see the built-in new insulators on the left side of this fig.

Fig. 1a: Detailed view of the insulator

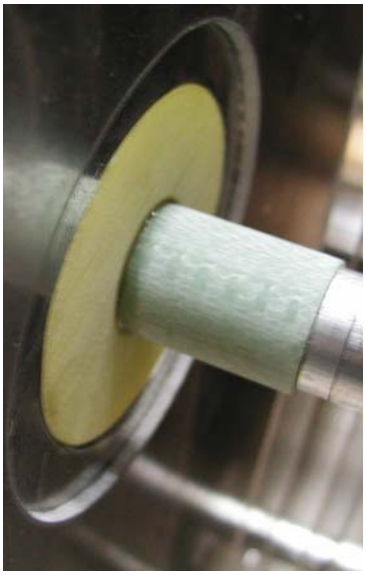

Fig. 1b: Detailed view of the built-in insulator

Fig.1c: Test arrangement; Ionizer with built-in insulators

2.2 Calculation of the electric field strength

To evaluate the stress due to the electric field strength of the insulator a calculation was performed using the method of finite elements. The calculation was done for the maximum of the operational voltage, which is limited up to 15 kV for the ionizer. For normal operation the working point is 12.5 kV. Fig. 2 shows the result of the calculated equipotential lines in the surrounding of the insulator. The maximum of the electric field strength was calculated with 2.6 kV/mm and it appears at the junction of the insulator to the grounded plate (smallest distance between the equipotential lines in fig. 2). The calculated value for the electric field strength is compatible with the dielectric strength of the used material for the insulator.

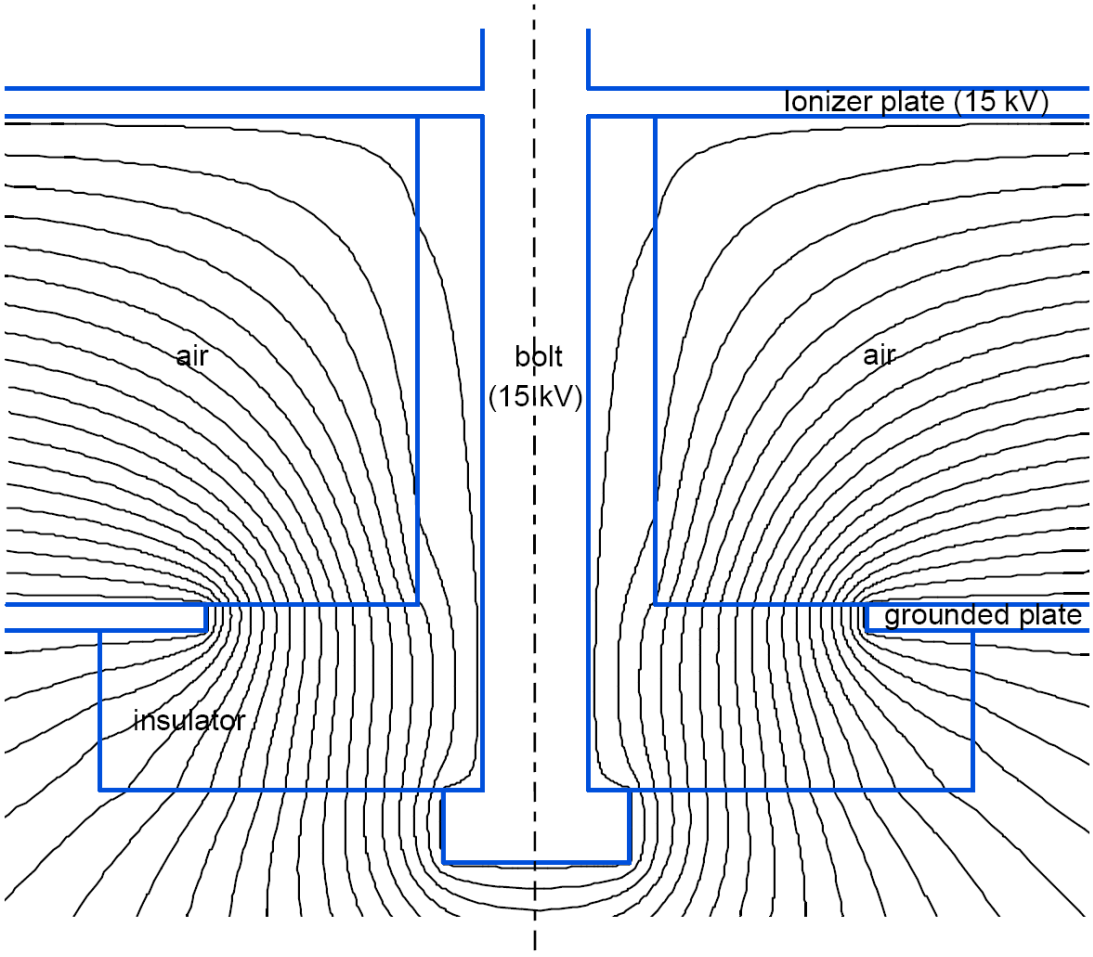

Fig. 2: Equipotential lines of the electric field in the surrounding of the insulator for the ionizer

2.3 High voltage tests

2.3.1 Breakdown voltage test

For the breakdown voltage test the arrangement as shown in fig. 3a was used. Due to the current limit of 4 mA of the used 35 kV high voltage supply only three ionizer plates with spikes have been built-in into the ionizer. The disruptive strength was measured with 21.5 kV. Spark-over during the breakdown voltage tests occurred always in the air gap between the spikes of the ionizer and the grounded plate as shown in fig. 3b. Due to this breakdown behaviour the new designed insulators are protected against flash-over.

Remark:
Spark-over in the air gap are not dangerous. Air is a so called "self healing insulation" without degradation and therefore air can't be destroyed electrically. However the solid insulating material is very sensitive against flash-over, which lead to an accelerated degradation of the insulating material (reduction of the creep resistance of the insulator's surface). Therefore the weakest part of a combined solid and gaseous insulating system always must be the gaseous part of the insulation.

Fig. 3a: Test arrangement for the breakdown voltage test

Fig. 3b: Air spark-over between the spikes of the ionizer and grounded plate

2.3.2 Voltage duration test

The voltage duration test was performed with 25 kV, which corresponds to the twofold value of the normal operational voltage of 12.5 kV. The total duration of the test was 500 h. To carry out this test it was necessary to remove all plates (spikes) of the ionizer due to the limiting breakdown voltage of 21.5 kV. After 400 h the test was interrupted to immerse the insulators into the cleaner for 48 h, which is used for the purification of the electrostatic precipitator during operation. To detect possible effects caused by the electric stress of the insulating material the insulation resistance of all 6 insulators of the ionizer has been measured before and after the duration test. The value of the insulation resistance for all 6 insulators was

> 1 Petaohm (10^{15} Ohm), measured before the beginning and after completing the test. The visual inspection of the tested insulators showed no conspicuousness.

3 Summary

For the insulator the highest value of the calculated electric field strength is 2.6 kV/mm for the maximal operational voltage of 15 kV This result shows, that the stress is compatible with the dielectric strength of the used material for the insulator. The result of the breakdown voltage test showed a value of 21.5 kV for the limit of the disruptive strength. The breakdown always occurred between the spikes and the grounded plate, which was required to protect the insulator's surface. The voltage duration test was performed with 25 kV and 500 h. All 6 insulators of the ionizer passed the test.