N₂ AND N₂/CO₂ MIXTURE IN GAS INSULATED COMPARTMENTS UNDER HIGH PRESSURE

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1. INTRODUCTION

SF₆ gas is widely used as insulating medium in high-voltage technology due to its nearly ideal insulating and switching behavior. Based on many years of experience SF₆ gas-insulated switchgear (GIS) is very compact and of highest reliability. Due to the discussions around the environmental potential of released SF₆ and also out of economic reasons alternatives to the insulating gas SF₆ had been looked for since long time in the past. According to today's consideration the most suitable insulating alternatives are nitrogen (N₂), carbon-dioxide (CO₂) and mixtures of both gases. For insulation and switching behavior no acceptable alternatives have been found. In comparison to the SF₆ technique the practical use of N₂ and/or CO₂ means basically a specific reduction in insulating strength with the result of a much larger design or a strong increase in gas pressure. N₂ and CO₂ have been widely and intensively investigated in the past, but only few investigations dealt with N₂ and N₂/CO₂ under extreme pressures up to 2.0 MPa in real size GIS compartments. It has been found that there is a wide spread in literature data of the electrical field strength of e.g. N₂ under 2.0 MPa (between 12 and 40 kV/mm) and most investigations had been performed by using small gas gaps with AC and DC test voltage only.

Contributing to the various investigations breakdown and withstand voltage tests on N₂ and N₂/CO₂ insulated GIS components have been performed to

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estimate their feasibility. Two different test setups were used:
- pure gas-gap configurations for basic tests,
- 245 kV GIS components including epoxy insulators for design tests.

2. BASIC INVESTIGATIONS BY USE OF GAS GAP

GIS components with pressure vessels applicable up to 2.0 MPa were used for basic investigations under N₂ and N₂/CO₂ (80%/20%) atmosphere in a cylindrical pure gas gap.

In the first basic tests the 50 Hz alternating (AC) withstand voltages and 1.2/50 μs lightning impulse (LI) withstand voltages at gas pressures 0.6, 0.9, 1.2, 1.5 and 1.8 MPa were determined. In addition the influences of surface roughness, coatings and imperfections were investigated. The test setup is shown in Figure 1. For a proper data basis the field distribution was calculated and the results are given as specific field strength values.

![Test setup for basic investigations up to 1.8 MPa](image)

**Figure 1**: Test setup for basic investigations up to 1.8 MPa

The testing procedure was standardized to obtain comparable test results for all different test series which were repeated at least three times. The results of the basic series with bare electrodes and without impurities are shown in Figure 2. For lightning impulse voltage, the withstand field strength increases generally with increasing pressure up to about 1.5 MPa. For N₂ LI withstand voltages with positive polarity are higher than those for negative polarity up to approx. 1.6 MPa. Within the investigated pressure range, the withstand field strengths of N₂/CO₂ gas mixture are remarkable higher than those of N₂. Up to 1.5 MPa the positive withstand values are higher than those of negative polarity, at higher pressures a reversal can be noticed. The lightning