Hybrid Gas-Insulation System

Background

SF_6 has been identified as a greenhouse gas with a long atmospheric lifetime. Therefore, recycling guidelines for SF_6 in electric power apparatus have been studied, and the reduction in the amount of SF_6 released into the atmosphere has progressed. In the long term, it is preferable to reduce the amount of SF_6 used. Therefore, it may be important to discuss the possibility of using environmentally friendly gases as an alternative insulation gas for practical gas-insulated apparatus.

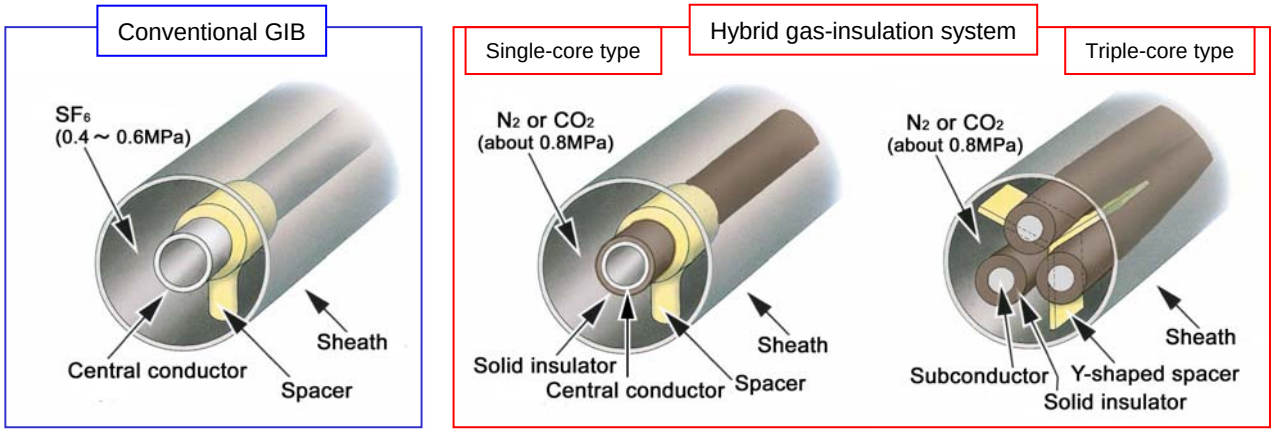
Principal results

In the selection of an alternative gas, high-pressure natural gases, such as air, nitrogen (N_2), and carbon dioxide (CO_2) are promising environmentally friendly candidates. However, some strategies for enhancing insulation performance are necessary for their practical applications to apparatus because the dielectric strengths of these gases are about 1/3 that of SF_6.

In this study, we investigated the possibility of gas-insulated apparatus using a hybrid gas insulation system. By applying the hybrid gas insulation system, a conventional SF_6-gas-insulated apparatus may be replaced with a natural-gas-insulated one without a considerable increase in cross-sectional size.

Future Developments

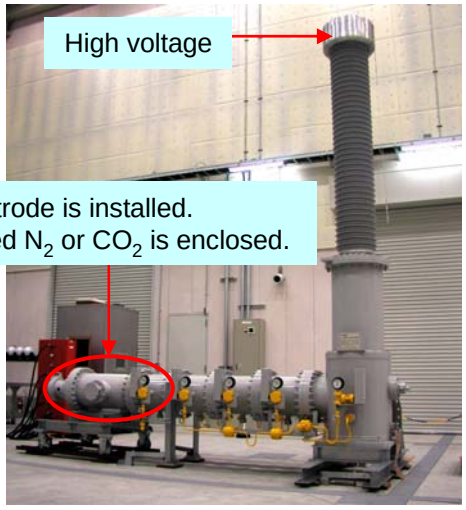
We are carrying on research on practical insulation performance of basic models for conductor joint to develop an environmentally-compatible gas-insulated apparatus using the hybrid gas-insulation system, and we aim at the proposition of the basic specification.



Basic structure of hybrid gas-insulation system (schematic illustration): The hybrid gas-insulation system has a structure which the high-electric-field part is insulated using a solid insulator. The triple-core type conductor structure is also supposed for the viewpoint of such as flexibility of the subconductors.

Basic research equipment (photo)

Model electrodes for conductor joint, etc. are installed in the basic research equipment. We are carrying out high voltage insulation tests for obtaining data for insulation design of hybrid gas-insulation system.



SF_6 is a colorless, odorless, and non-toxic gas. It has been applied to gas-insulated power apparatus owing to its excellent insulation and interruption performance. Moreover, it has been used by the magnesium industry, etc. other than electric power equipment. However, it has been identified as a greenhouse gas with a long atmospheric lifetime. Therefore, the amount of SF_6 released into the atmosphere has been reduced by each industry.

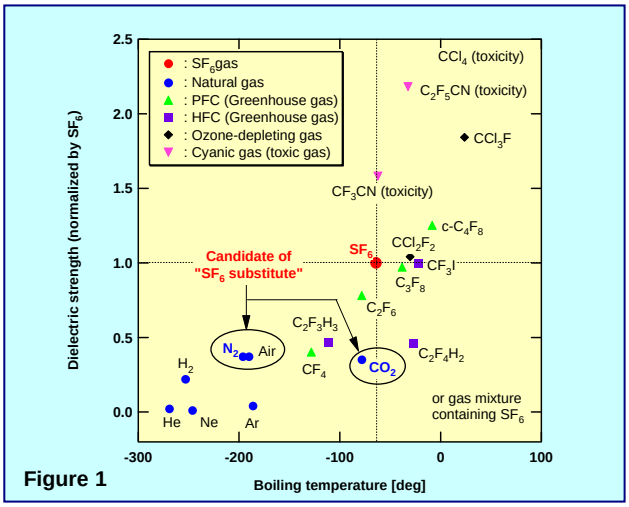


Figure 1

Search of SF_6 substitute

Figure 1 shows dielectric strengths in different gases normalized by that in SF_6 as functions of boiling temperature. In the selection of an alternative gas, it should be noted that an artificial gas in which a high dielectric strength is achieved often has some environmental restriction. Therefore, it is thought that high-pressure natural gases, such as air, nitrogen (N_2), and carbon dioxide (CO_2), are promising environmentally friendly candidates.

In this study, we assume the complete substitution of SF_6 by a pure environmentally friendly gas (natural gas), although we also assume the use of a gas mixture as the target gas from the viewpoint of the reduction in the amount of SF_6 used.

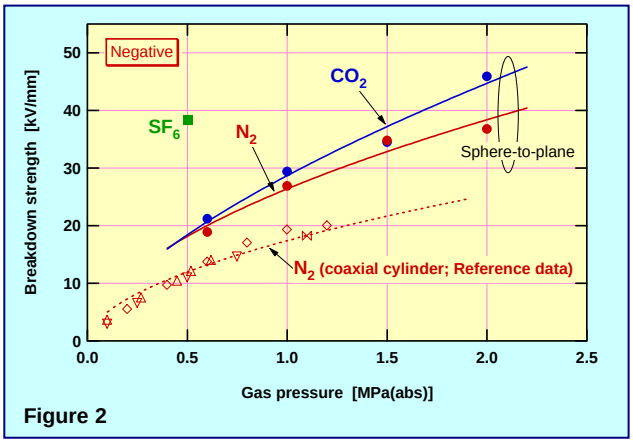


Figure 2

Insulation performance of compressed natural gases (N_2 & CO_2) compared with SF_6

Figure 2 shows breakdown strengths of N_2, CO_2 and SF_6 as functions of gas pressure. In general, the breakdown strength of gases increase with the gas pressure. The breakdown strength in CO_2 of approximately 1.5MPa or in N_2 of approximately 2.0MPa is nearly equal to that in SF_6 of 0.5MPa (practical use). However, gas insulated equipment at a gas pressure of 3 or 4 times higher than conventional one is not practical.

Therefore, some strategies for enhancing insulation performance are necessary for the practical applications of these gases. By applying the hybrid gas insulation system, a conventional SF_6-gas-insulated apparatus may be replaced with a natural-gas-insulated one without a considerable increase in cross-sectional size. In the case of applying gases such as N_2 and CO_2, the use of the hybrid gas insulation system may be effective as a method of achieving a higher insulation performance.

Feature of hybrid gas-insulation system

Hybrid gas-insulation system has many advantages for electrical insulation such as electric field distribution, insulation performance with presence of metallic particles.

	Single-core type	Triple-core type
Electric field distribution	○Reduction of maximum electric field strength in gas ○Uniformity of electric field distribution	●Maximum electric field is higher than that of single-core. ○Reduction of highly stressed part (area) of conductor
Insulation characteristics under clean condition & with metallic foreign object	○Improvement of breakdown strength under clean condition (increase of allowable electric field) ○Little influence of degradation of solid insulator by electric field stress ○Improvement of insulation reliability by avoiding the attachment of metallic particle on conductor ○The harmful effect of a conducting particle may be reduced because discharge in the gas does not cause sudden breakdown (short-circuit or earth fault).	
Spacer	●It is necessary to consider triple junction like the conventional apparatus	○The support points do not constitute weak points in the insulation.
Conductor joint	●It is necessary to consider insulation performance for the interface of solid insulator.	
Construction		○Flexibility of subconductor

(○: advantage, ●: Problem)

Future development of hybrid gas-insulation system

By applying the hybrid gas insulation system, a conventional SF_6-gas-insulated apparatus may be replaced with a natural-gas-insulated one without a considerable increase in cross-sectional size. To develop an environmentally-compatible gas-insulated apparatus using the hybrid gas-insulation system, we are carrying on research on the following problems, and we aim at the proposition of the basic specification.

(1) Insulation design
(2) Thermal design
(3) Technology of conductor joint and conductor support
(4) Estimation of basic specification
(5) Estimation of life cycle cost and life cycle assessment