



ANEXO G.- Documentos científicos encontrados en la búsqueda que mencionan el uso de SF6 y otros gases aislantes en celdas eléctricas

Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Major Electrical Equipment Proposed for Tidal Power Plants in the Bay of Fundy	Seoni, R.M.	Canadian Atlantic Power Group (Acris Consulting Services Limited)	Power Apparatus and Systems, IEEE Transactions on	1979	The paper discusses general considerations and future possibilities for the design of generating equipment for tidal power plants with particular reference to Bay of Fundy sites. Factors affecting the design of turbines, generators, excitation system, powerhouse layout and the main electrical connections are reviewed. Various alternatives for transmission of power to shore are listed and the choice of SF6 gas insulated bus duct is substantiated by comparative data. Advantages of integrating the high-voltage switching station with the powerhouse, using SF6 gas insulated metal-clad switchgear are discussed. Application of computers and microprocessors is envisaged. The paper concludes that advances in technology can make a significant contribution to economic development of tidal power.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4113683
Influence of a metallic particle at a metal/insulator/gas triple junction in air and SF6	Caliap, L.; Lesaint, O.; Denat, A.; Bonifaci, N.; Blanchet, G.; Girodet, A.; Gelloz, B.	Grenoble Electr. Eng. Lab. (G2Elab), INPG & Univ. Joseph Fourier, Grenoble, France	Electrical Insulation and Dielectric Phenomena, 2009. CEIDP '09. IEEE Conference on	2009	In gas insulated switchgears (GIS), high voltage electrodes are supported by solid insulators. A "triple junction" (TJ) exists at the interface between metal, insulating solid, and gas. This area constitutes a preferential zone where partial discharges (PDs) can appear. A further degradation of insulation performance can occur if solid particles accumulate at that place. This paper presents experiments carried out to obtain a quantitative account of the influence of a metallic particle located close to a triple junction area, both in dry air and SF6. PDs are detected and measured by conventional electrical measurements, and observed optically with a high-sensitivity intensified camera. Measurements under AC voltage show the influence of the particle on PD inception and flash-over voltage, in comparison with the same geometry without particle. In SF6, the particle induces a large decrease of PD inception and breakdown voltages, which become nearly independent of the gas pressure.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5377865



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Evaluation of breakdown characteristics of gas insulated switchgears for non-standard lightning impulse waveforms - method for converting non-standard lightning impulse waveforms into standard lightning impulse waveforms -	Okabe, S.; Yuasa, S.; Kaneko, S.; Ueta, G.	High Voltage & Insulation Group Tokyo Electr. Power Co., R & D Center, Yokohama	Dielectrics and Electrical Insulation, IEEE Transactions on	2009	To lower the lightning impulse withstand voltage of gas insulated switchgear (GIS) while maintaining the high reliability of its insulation performance, it is important to define in an organized way the insulation characteristics for non-standard lightning impulse voltage waveforms that represent actual surge waveforms in the field and compare them with the characteristics for the standard lightning impulse waveform quantitatively. In the preceding researches, lightning surge waveforms and disconnecter switching surge waveforms at UHV, 500 kV, and 275 kV substations were analyzed and five to six kinds of non-standard lightning impulse waveforms with basic frequencies of 0.6 to 5.0 MHz were identified. Then, the dielectric breakdown voltage iquest time characteristics were measured under several different conditions on the quasi-uniform SF6 gas gaps and partly the coneshaped insulating spacers that represent insulation elements of GIS for six kinds of nonstandard lightning impulse waveforms. In this paper, the resultant breakdown voltages were evaluated in terms of the overvoltage duration, which led to their formulation in a unified way. On the basis of these insulation characteristics and their unified formulation, the paper investigated a method for converting non-standard lightning impulse waveforms into standard lightning impulse waveforms with equivalent stress for the insulation. When the constructed algorithm was applied to five examples of representative two type waveforms in the lightning surge time region, they were converted into standard lightning impulse waveforms with crest values reduced by 20% to 34%, suggesting potentiality for reduction of lightning impulse insulation specifications of GIS.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4784550



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Insulation characteristics of various conditions for eco-friendly high voltage switchgear	Lee, J.H.; Ryu, J.S.; Joo, H.W.; Tak, S. J.; Park, S.W.; Lee, J.H.	LS Ind. Syst. Co., Cheongju, South Korea	Electrical Machines (ICEM), 2010 XIX International Conference on	2010	High voltage applications often use SF6 gas insulation and arc extinguishing medium. However, SF6 gas was specified as a greenhouse gas in the Kyoto protocol in 1997 and the manufactures of electric power equipments try to replace SF6 gas with another eco-friendly insulation medium. In this paper, the various insulation conditions of bus system of gas insulated switchgear were analyzed by finite element method and lightning impulse tests were performed to compare dielectric strength of each condition. Dry-Air and mixed gas with SF6 and Dry-Air, is considered as substitution of insulation medium and the epoxy coated surface of current carrying conductor as an addition of insulation material.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5607957



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Insulation breakdown characteristics of UHV-class gas insulated switchgear for lightning impulse withstand voltage test waveform - K-factor value and front time related characteristics	Tsuboi, T.; Ueta, G.; Okabe, S.; Miyashita, M.; Inami, K.	R&D Center, Tokyo Electr. Power Co., Yokohama, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2011	<p>The lightning impulse withstand voltage test waveform for electric power equipment is specified in IEC 60060-1 "High-voltage test techniques" as revised in 2010. At present, test standards for UHV-class equipment are under study. Increasing equipment capacity and the digitization of measuring equipment are mentioned as these backgrounds. Withstand voltage test by the standard waveform specified in the previous standard had been difficult (it eventually becomes an overshoot waveform) with increasing equipment capacitance. In response, an evaluation method using the kfactor function (test voltage function) was introduced, whereby the overshoot waveform was converted to the test voltage waveform. To date, concerning these kfactor values, measurement results based on experiments have been reported, but most were from small-scale insulation models with breakdown voltage levels mainly around 100 kV. The present study reports the experimental results of the insulation breakdown characteristics for the lightning impulse withstand voltage test waveform in the largest SF6 gas insulation model possible assuming actual UHV-class gas insulated switchgear. Breakdown voltage and breakdown time were measured with the superimposed oscillation frequency, overshoot rate, and front time as parameters. Following evaluation of the k-factor value based on these experimental results, the k-factor value with the overshoot rate of 10% was almost identical to that of the existing k-factor function. Consequently, evaluation using the existing k-factor function is considered appropriate. Subsequently, the existing k-factor function is most likely to be effective also for UHV-class equipment. In addition, it emerged that changes in the insulation breakdown characteristics due to the extension of the front time were small. It was considered that extending the front time, rather than allowing an excessive overshoot rate, would enable proper verification of the insulation performance as part of standard assuming UHV-class equipment.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6032845



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
On-line and long-term monitoring and diagnosis system for insulation on switchgear devices by wireless communication technique	Cheng-Chien Kuo; Hong-Chan Chang	Dept. of Electr. Eng., St. John's Univ., Taipei, Taiwan	Condition Monitoring and Diagnosis (CMD), 2012 International Conference on	2012	An on-line partial discharge detection instrument for SF6-insulated switchgear using wireless communication technology is proposed. Two major parts is divided for the developed instrument. One is the remote wireless monitoring with on-line measurement unit that could be placed permanently onto the SF6-insulated switchgear equipment so as to measure the partial discharge signal from an ultrasonic sensor. The other is the server analysis and calculation unit. It is mainly composed of an industry computer containing a wireless module. The function of this unit is to collect, analyze and store the ultrasound signal captured from each remote monitoring unit, and to perform software-based signal noise and interference reduction. Through feature extraction of the original ultrasound signal, a digitalized assessment and recognition system of the state of insulation could be created.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6416242
Study on GIS substation for the insulation coordination	Wang Dahu; Wu Bing; Lu Hui; Hu Zhiguo	Sch. of Electr. Eng. & Autom., Henan Polytech. Univ., Jiaozuo, China	Circuits, Communications and System (PACCS), 2010 Second Pacific-Asia Conference on	2010	Early warning system based on the detection of UHF SF6 partial discharge (PD) signals is a necessary means for the protection of Gas-Insulated Switchgear (GIS) in service as well as the power system to which it is connected. In order to ensure the safe and reliable operation of GIS, it is important to adopt an effective diagnosing method, which is able to identify signals of harmful defects promptly.. Although, a number of insulation coordination studies have discussed controlling over-voltages due to lightning and switching in Gas Insulated Switchgear (GIS) and transformers, not many deal with the additional complexity raised when cables are used to connect overhead lines to the new equipment. An introduction is provided to the sensitivities which affect the magnitude of fast front transients occurring in a typical arrangement including overhead-lines connected to GIS and transformers using short cable sections. This considers factors including lightning, cable length, tower footing impedance and substation running arrangements. Generic sensitivities will be examined for a 400 kV circuit, using studies carried out in EMTP to establish the nature of these over-voltages within the substation and the effectiveness of control methods to mitigate their impact.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5626946



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Evaluation of breakdown characteristics of gas insulated switchgears for non-standard lightning impulse waveforms - breakdown characteristics for non-standard lightning impulse waveforms associated with disconnector switching surges -	Okabe, S.; Yuasa, S.; Kaneko, S.	High Voltage & Insulation Group, Tokyo Electr. Power Co., Yokohama	Dielectrics and Electrical Insulation, IEEE Transactions on	2008	To lower the insulation specifications (specifically, the lightning impulse withstand voltage) of a gas insulated switchgear (GIS) and thus cut the equipment cost while maintaining the high reliability of its insulation performance, it is necessary to define in an organized way the insulation characteristics for non-standard lightning impulse voltage waveforms that represent actual surge waveforms in the field and compare them with the characteristics for the standard lightning impulse waveform quantitatively. In the preceding paper, lightning surge waveforms and disconnector switching surge waveforms at UHV, 500 kV, and 275 kV substations were analyzed and five to six non-standard lightning surge waveforms with basic frequencies of 0.6 to 5.0 MHz were identified. In this paper, the dielectric breakdown voltage - time characteristics were measured under several different conditions for the quasi-uniform SF6 gas gap that represents an insulation element of a GIS toward two kinds of non-standard lightning impulse waveforms associated with disconnector switching surges. As a result, in the tested range, the dielectric breakdown values for non-standard lightning impulse waveforms were higher than for the standard lightning impulse waveform by 6% to 36%.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4543109
Application of solid insulated materials on medium voltage switchgear of distribution lines	Menglei Zheng; Ji Hoon Ma; Lyun Yu; Seog Won Lee; Young Geun Kim; Yang Seob Sin; Jong Heok Lee; Sung Yon Won	Electro-Technol. R&D Center, LS Ind. Syst. Co. Ltd., Cheongju, China	Electricity Distribution (CICED), 2010 China International Conference on	2010	For medium voltage and high voltage class, SF6 gases are widely used for insulating materials for most of the switchgears at distribution lines because of its superior electrical insulating quality. However, this SF6 gas belongs to one of 6 greenhouse gases which have to be reduced each year by complying with the Kyoto's protocol signed in 1997. So many researches are made by power equipment companies for the purpose of finding out appropriate alternative material for SF6 gas. Recently, epoxy is proved to be a high insulation reliability and eco-friendly used on electrical equipments. This paper introduces a kind of epoxy molded Solid Insulated Switchgear (SIS) for medium voltage class.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5736191



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
50 years in the development of insulating liquids	Fofana, I.	Dept. of Insulating Liquids & Mixed Dielectr. for Electrotechnol. (ISOLIME), Univ. du Quebec a Chicoutimi, QC, Canada	Electrical Insulation Magazine, IEEE	2013	<p>The role of electrical insulation is critical for the proper operation of electrical equipment. Power equipment cannot operate without energy losses, which lead to rises in temperature. It is therefore essential to dissipate the heat generated by the energy losses, especially under high load conditions. Failing to do so results in premature aging, and ultimately to failure of the equipment. Heat dissipation can be achieved by circulating certain liquids, which also ensure electrical insulation of energized conductors. The insulating-fluids market is therefore likely to be dominated by liquids, leaving to gases (such as compressed air and SF6) limited applications in power equipment such as circuit breakers and switchgear [1]-[3]. Several billion liters of insulating liquids are used worldwide in power equipment such as transformers (power, rectifier, distribution, traction, furnace, potential, current) [4], resistors [5], reactors [6], capacitors [7], cables [8], bushings [9], circuit breakers [10], tap changers [11], thyristor cooling in power electronics, etc. [12]. In addition to their main functions of protecting solid insulation, quenching arc discharges, and dissipating heat, insulating liquids can also act as acoustic dampening media in power equipment such as transformers. More importantly, they provide a convenient means of routine evaluation of the condition of electrical equipment over its service life. Indeed, liquids play a vital role in maintaining the equipment in good condition (like blood in the human body). In particular they are responsible for the functional serviceability of the dielectric (insulation) system, the condition of which can be a decisive factor in determining the life span of the equipment [13]. Testing the physicochemical and electrical properties of the liquids can provide information on incipient electrical and mechanical failures. In some equipment, liquid samples can be obtained without service interruption.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6585853



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Development of SF ₆ -Free 72.5 kV GIS	Rokunohe, T.; Yagihashi, Y.; Aoyagi, K.; Oomori, T.; Endo, F.	Hitachi Ltd., Ibaraki	Power Delivery, IEEE Transactions on	2007	<p>This paper describes the fundamental insulation characteristics of environmentally friendly gases; dry air, N₂ and N₂ O₂ mixed gas. Conventional gas insulated switchgear (GIS) generally uses SF₆ as against over 72.5 kV class. We have proposed GIS with a vacuum circuit breaker against from 72.5 kV class to 170 kV class as SF₆-free GIS. Because the insulation gas of this type of SF₆-free GIS has the hardly unnecessary current interception performance, the optimal insulation gas can be selected based on fundamental insulation performance. From the standpoints of insulation performance and economical efficiency, we selected compressed dry air as the optimal insulation gas for this type of SF₆-free GIS. However, the dielectric strength of dry air is approximately one-third that of SF₆ gas. Therefore, to achieve roughly the same size as conventional GIS, some strategies must be employed to enhance insulation performance. This paper investigates the influence of gas pressure and a gas/solid hybrid insulation structure. The insulation performance of the gas/solid hybrid insulation structure using an insulation coating was found to be better than that of a barrier. Moreover, the dielectric strength of particles adhering to a spacer under the compressed dry air was about 1.5 times higher than that under N₂. Thus, the high insulation reliability of the gas/solid hybrid structure was high against particles was confirmed. In view of these investigative findings, this type of SF₆-free 72.5 kV GIS which was designed and manufactured, was confirmed to comply with the IEC standard.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4265720



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Evaluation of breakdown characteristics of N ₂ gas for non-standard lightning impulse waveforms - breakdown characteristics in the presence of bias voltages under non-uniform electric field	Wada, J.; Yamamoto, K.; Ueta, G.; Okabe, S.	Tokyo Electr. Power Co., Kanagawa, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2013	SF6 gas, an insulation medium used for gas insulated switchgear (GIS), has a high global warming potential, hence the search for an effective alternative is required from an environmental perspective. As one potential alternative, the authors are focusing on N ₂ gas, which has relatively good insulation characteristics among gases with a low environmental impact. To use this N ₂ gas for actual GIS, the insulation characteristics for actual overvoltage waveforms generated in the field (non-standard lightning impulse waveforms; non-standard-LIWs) must be obtained. The present study obtained and evaluated the insulation characteristics where a surge occurred in the presence of a bias voltage (dc component), which was considered realistic and severe under a non-uniform electric field typically represented by metallic particles. Consequently, it was concluded that the breakdown voltage was lower for positive polarity under a non-uniform electric field in the presence of a bias voltage and that it was appropriate to conduct an experiment using a positive polarity waveform when studying dielectric strength. Furthermore, it emerged that the breakdown voltage for a positive polarity waveform was 1.06 to 1.67 times higher than that for the standard lightning impulse waveform, even if the frequency and damping rate were changed. These results support the rationalization of insulation for actual surge waveforms under the quasi-uniform electric field.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6571458



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Evaluation of breakdown characteristics of CO ₂ gas for non-standard lightning impulse waveforms - Method for converting non-standard lightning impulse waveforms into standard lightning impulse waveforms -	Ueta, G.; Wada, J.; Okabe, S.	Tokyo Electr. Power Co., Yokohama, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2011	SF ₆ gas, an insulation medium used for gas insulated switchgear (GIS), has a high global warming potential, hence an effective alternative means is expected from the environmental perspective. The authors are focusing on CO ₂ gas, which has a lower global warming potential, as one of its potential alternatives. To use this CO ₂ gas for the actual GIS, the insulation characteristics for overvoltage waveforms generated in the actual fields (non-standard lightning impulse waveforms) must be obtained. For this purpose, the preceding study experimentally obtained and evaluated the insulation characteristics for various non-standard lightning impulse waveforms covering the surge waveforms generated in the actual field. In the present paper, the experimental results accumulated to date were comprehensively handled to conduct a study on the evaluation method of the insulation characteristics of the CO ₂ gas gap for non-standard lightning impulse waveforms. Consequently, similarly to the previous study using SF ₆ gas, the insulation characteristics could be expressed by one characteristic line using the duration as a parameter. Furthermore, after establishing an evaluation method of the insulation specification for generated waveforms based on the characteristic line and applying it to actual surge waveforms at substations as an example, it emerged that the insulation specification could potentially be reduced by about 10%.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6032844



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
A Novel Technique for Detecting Electromagnetic Waves Caused by Partial Discharge in GIS	Hoshino, T.; Kato, K.; Yayakawa, N.; Okubo, H.	Department of Electrical Engineering, Nagoya University, Nagoya, Japan	Power Engineering Review, IEEE	2001	For the insulation diagnosis of gas-insulated switchgear (GIS), it is necessary to detect partial discharge (PD) under noisy conditions and to specify the direction of electromagnetic wave radiation due to PD. We propose the "phase gate control method" for discriminating the electromagnetic waves caused by PD in SF6 gas from external noises. The proposed method enables us to discriminate PD of about 100 pC in SF6 gas from external noises of more than 10,000 pC in air. We also compare polarization characteristics of electromagnetic waves radiated from PD with those from a half-wave dipole antenna and estimate the radiation length of electromagnetic waves caused by PD. The results derived in this paper will contribute greatly to the insulation diagnosis of GIS on site.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4311486
An Approach to the Suppression of Sheath Surge Induced by Switching Surges in a GIS/Power Cable Connection System	Ishikawa, M.; Oh-hashii, N.; Ogawa, Y.; Ikeda, M.; Miyamoto, H.; Shinagawa, J.	Tokyo Electric Power Co., Inc.	Power Apparatus and Systems, IEEE Transactions on	1981	This paper deals with surges induced in the sheath of a SF6 gas insulated switchgear (GIS)/power cable connection system. High frequency switching surges generated from the GIS, in turn, induce sheath surges across insulation sleeves located at GIS/power cable connection points and at cable cross-bonded points.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4110634



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
News from Japan	Ohki, Y.		Electrical Insulation Magazine, IEEE	2010	Switchgear is an essential component of electric power networks for transmitting and distributing power and is installed in all related facilities. More than 100 years have passed since it was introduced. Air-insulated switchgear, which was vulnerable to dust and humidity, was used until the 1970s. Then a new gas-insulated switchgear (GIS) using sulfur hexafluoride (SF ₆) gas, much superior in electrical insulating performance, was developed. However, in recent years SF ₆ has been designated as a greenhouse gas, and the electric power industry has been working to reduce its use. One way is to use highpressure air for insulation. However, such devices are inevitably bigger than the corresponding SF ₆ devices, and they require pressure vessels. Another option is to use solid insulation. The electric strength of a typical epoxy compound is three times that of SF ₆ , and so smaller body size is practicable in an environmentally friendly solid-insulated switchgear (SIS). However, because of the difference in the coefficients of thermal expansion between ceramic and epoxy compounds, conventional epoxy compounds have insufficient mechanical strength to withstand internal stresses caused by differential expansion. Thus it is necessary to develop a highperformance epoxy compound that can be directly molded into a vacuum interrupter consisting of ceramic tubes.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5599983
News from Japan	Ohki, Y.		Electrical Insulation Magazine, IEEE	2009	In an attempt to reduce global warming, much research and development work has been done on electric power equipment in which SF ₆ gas insulation is not used. Mitsubishi Electric Corporation, Tokyo, which released 24-kV-rated dry air insulated switchgear in 2000, has completed more than 1,000 switchgear installations in the 12-, 24-, and 36-kV classes. Recently, the company developed 72-kV-rated switchgear which features low-pressurized dry air (gauge pressure < 0.2 MPa-g) insulation, improved electromagnetic actuators and condition-based maintenance (CBM) functions.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4795475



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Vacuum disconnectors: Acceptability issues	Picot, Philippe	Schneider Electric - France	Electricity Distribution, 2005. CIRED 2005. 18th International Conference and Exhibition on	2005	SF6gas is widely used in MVdistribution switchgear because of its outstanding performances in fulfilling the three functions : switching insulation and disconnection. However it has been identified as a green-house gas whose release in atmosphere should be avoided : therefore other technologies are considered to substitute SF6, such as vacuum switching and solid insulation. Recently vacuum interrupters (Vis) have been proposed also to perform the disconnecting function : the purpose of this paper is to evaluate the suitability of vacuum technology for this application. The first part about disconnectors in general is a reminder of their definition, purpose and technical requirements. The second is centred on the properties of vacuum insulation and its suitability to provide a reliable isolating distance between open contacts. The third is a review of various solutions proposed to overcome the difficulties raised by the use of vacuum as an insulating medium for disconnecting function. Finally the acceptability of these solutions is discussed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5428161
IEEE Standard Definitions for Power Switchgear			IEEE Std C37.100-1992	1992	In this standard, terms that encompass the products with the scope of the C37 project are defined. These include power switchgear for switching, interrupting, metering, protection and regulating purposes as used primarily in connection with generation, transmission, distribution, and conversion of electric power. The definitions do not purport to embrace other meanings that the terms may properly have when used in connection with other subjects.<<ETX>>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=182886



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Investigation of long-term reliability for solid insulated switchgear	Sato, J.; Shioiri, T.; Imai, T.; Tagaya, O.; Takei, Y.; Kuriyama, T.; Homma, M.	Power & Ind. Syst. R&D Center, Toshiba Corp., Fuchu, Japan	Transmission and Distribution Conference and Exposition (T&D), 2012 IEEE PES	2012	SF ₆ gas is applied widely to medium voltage switchgear because of its high insulation reliability and down-sizing ability. However, SF ₆ gas was placed on the list of greenhouse gases under the Kyoto Protocol in 1997. Since then, the investigation and development concerning SF ₆ free or less has carried out activity. Therefore, we focused on solid materials with higher dielectric strength than SF ₆ , and we have developed solid insulated switchgear (SIS) achieved by molding all main circuit. A new epoxy casting material is applied, which contains a great deal of spherical silica and a small amount of rubber particles. This new material has the high mechanical strength, high thermal resistance, high toughness, and also high dielectric strength because of directly molding the vacuum bottle, as well as reduced size and high reliability. This paper describes about the long-term reliability of SIS using a new epoxy casting material. We carried out seismic tests, heat cycle tests, heat shock tests and long-term withstand voltage tests for about 5 years. As a result, it was confirmed that SIS had an excellent characteristics in all tests. The effectiveness of the development material and the reliability of SIS were verified.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6281516



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Partial discharge diagnosis of Gas Insulated Station (GIS) using acoustic method	Suwarno; Caesario, P.; Anita, P.	Sch. of Electr. Eng. & Inf., Inst. Teknol. Bandung, Bandung, Indonesia	Electrical Engineering and Informatics, 2009. ICEEI '09. International Conference on	2009	This document recently, gas insulated switchgear (GIS) is widely used in electrical system. This is due to the fact that GIS has many advantages compared with other types of switchgear, like more efficient space for installation and better protection from pollution. However, GIS is still vulnerable to operation malfunction and even breakdown caused by defects within it. One of the methods to assess GIS insulation condition is by diagnosing partial discharges that occur within GIS which caused by the aforementioned defect. This final project reports the presence of partial discharges in the GIS compartments which have decomposition level above CIGRE standard of 1000 ppm using acoustic emission method. Based on the PD measurement result, insulation condition of GIS was investigated. This diagnosis were done in Gunung Salak substation. From this research it is known that possible source of defect within GIS such as protrusion, free particle, or loose shields, can be detected using acoustic emission method.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5254733
Bibliography of gas insulated substations			Power Apparatus and Systems, IEEE Transactions on	1975	In 1970, due to the developing interest in North America in gas insulated substations, the IEEE Substations Committee established Working Group 70.1 on Gas Insulated Substations. Interest in these substations has continued to grow since then and an increasing number of articles have been written on the subject each year. Working group 70.1 has therefore prepared this bibliography of most of the readily available English language literature on gas insulated substations. Articles are arranged in chronological order in one of three general categories: gas insulated substations, gas insulated transmission lines and dielectric properties of SF6 gas insulation. This bibliography was prepared by G.H. Hathaway, R. Matulic and P.R. Nannery for Working Group 70.1 on Gas Insulated Substations of the IEEE Substations Committee.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1601583



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Spacer Flashover in SF6 under Steep-fronted Impulse Voltages	Chen Qingguo; Wang Yonghong; Xinlao Wei	Sch. fo Electr. & Electron. Eng., Harbin Univ. of Technol.	Properties and applications of Dielectric Materials, 2006. 8th International Conference on	2006	Very fast transient overvoltages (VFTO) might result from flashover of the particle-contaminated spacer in gas-insulated switchgear (GIS). To get a better understanding of the effects of voltage wavefront steepness and oscillation frequency on the flashover voltage, experiments were carried out on a simple cylindrical spacer with a metallic protrusion under different voltage waveforms. The results show that the flashover voltage-time (V-t) characteristics are dependent on oscillation frequency and rise time of impulses. The space charge accumulation produced by corona discharge of the metallic particle on the spacer is the main reason that causes the insulation failure of GIS.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4062773
IEEE Draft Guide for Gas-Insulated Substations Rated Above 52 kV			IEEE PC37.122.1/D13, January 2013	2013	This guide provides information of special relevance to the planning, design, testing, installation, operation and maintenance of gas-insulated substations(GIS) and equipment. This guide is intended to supplement IEEE Std C37-122-1993(R2002). This guide is applicable to all gas-insulated substations (GIS) above 52 kV. However, the importance of topics covered varies with application category. For example, the issues related to advanced field test techniques and very fast transients (VFT) are of particular interest for extra high voltage (EHV) gas-insulated substations (GIS).	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6646181



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Benefits of proper SF6 handling to reduce SF6 emissions for sustainable Electricity Transmission and Distribution	Biasse, J.; Otegui, E.; Tilwitz-von Keiser, B.	Energy BU usine 38V, Schneider Electr., Grenoble, France	Electricity Distribution (CICED), 2010 China International Conference on	2010	<p>Technologies depending on Sulphur hexafluoride, as an insulation and current breaking medium, are used in high and medium voltage switchgear. Sulphur hexafluoride (SF₆) has a number of attractive properties for current breaking. It is a superior dielectric medium, it has very good arc-switching properties and it is chemically inert, non-toxic and non-flammable. On the other hand, SF₆ has a global warming potential of 22.800 compared to CO₂, and is one of the gases listed by the Kyoto Protocol to be monitored. Nevertheless, due to its very low concentration in the atmosphere, its contribution to anthropogenic warming is very low. Unfortunately, a functionally equivalent alternative to SF₆ as an insulating and arc extinguishing medium does not exist. Aware of this, the European electrical industry represented by the T&D Europe manufacturers association has reinforced its actions in different directions to drastically reduce SF₆ emissions. These actions are applied all along the life cycle of SF₆, from procurement, production, design and manufacturing of electrical switchgear, operational life in grids, where tightness is critical and at end of life treatment. In some countries, all involved parties have signed voluntary agreements with their local Environmental Protection Agencies, committing to apply measures for effective SF₆ emissions reductions</p> <p>Documentation and standardization aspects as well as legal aspects are now available and consistent to properly manage SF₆ in the electrical industry. The general IEC standardization process - based on CIGRE papers [7], [22], [20] - has already introduced requirements covering SF₆ since 1970. It is regularly updated to include the latest improvements in best available techniques. For example the current technical report IEC/TR 62271-303 is going to become an international standard (IEC 62271-4) to enable it to be used more widely and possibly to be referenced in some regulations. In the meantime, many regulations have been put in place, all over the world, with the same objective. For example, the European Regulation 842/2006 that regulates certain fluorinated greenhouse gases demands SF₆ recovery by certified personnel; dedicated labelling of SF₆ filled electrical equipment and reporting of some SF₆ data. Thanks to these best available practices, it is now proven by an international study that applying them on a worldwide basis can lead to significant SF₆ emissions</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5736185



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Dielectric Characteristics of Gas Insulated Bushings in Air Under Dry and Wet Conditions	Yamagiwa, T.; Kamata, Y.; Yoshioka, Y.; Hosokawa, M.	Hitachi Research Laboratory, Hitachi, Ltd.	Power Apparatus and Systems, IEEE Transactions on	1981	Dielectric characteristics of an EHV gas insulated bushing to be used for SF ₆ gas insulated switchgears are reported. From observation of the lightning impulse flashover under dry conditions with an image converter camera, the flashover process of the bushing in air is clarified. It was found that the electric field strength of the porcelain surface on the lower part of the bushing had a large influence on insulation performance. The tilt angle of the bushing was changed as a result of studying the switching impulse dielectric characteristics of the bushing under wet conditions; and the water stream on the exterior surface of the bushing was seen to have a large influence. It was demonstrated that dividing the water flow along the porcelain surface made an improvement in insulation performance.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4110934
Advanced Metal Oxide Surge Arrester For Gas Insulated Switchgear (GIS)	Imataki, M.; Ujita, K.; Fujiwara, Y.; Ishibe, S.; Nitta, T.	Mitsubishi Electric Corporation	Power Apparatus and Systems, IEEE Transactions on	1984	SF ₆ gas has outstanding dielectric strength and heat transfer property. This suggests that zinc oxide (ZnO) elements whose value of E in E-J characteristic is higher than the value of the elements used in a porcelain type arrester is suitable to metal enclosed metal oxide surge arresters (MOA) for gas insulated switchgears (GIS). Several kinds of newly developed ZnO elements with the high values of E and their practical performances are discussed in this paper. The application of these elements realizes more compact and simpler arresters which have outstanding protection performance for GIS.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4112402



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
DC Dielectric Strength of a SF6 Gas Insulated System	Menju, S.; Takahashi, K.	Tokyo Shibaura Electric Co., Ltd.	Power Apparatus and Systems, IEEE Transactions on	1978	The breakdown characteristics of gas insulated systems were investigated for DC and switching impulse voltage superposed upon DC of opposite polarity in laboratory-clean conditions. The breakdown voltage of a SF6 gas gap for DC voltage is approximately 80 percent of that for AC crest value at pressure of 3.5kg/cm2 abs., while an epoxy cast gap withstands the DC voltage by 1.7 times of the AC crest value. However, when the short epoxy cast gap is subjected to the combined voltage of DC and switching impulse of reverse polarity, the switching impulse breakdown voltage is strongly affected by the preset level of DC voltage. On the other hand, the superposed switching impulse breakdown voltages of conical insulators, for supporting a high voltage conductor in a cylindrical enclosure, are only slightly influenced by the DC voltage of reverse polarity. Therefore the combination of SF6 gas and epoxy resin may be used effectively as an insulation system of the HVDC gas insulated substation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4181416



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Partial discharge detection for GIS: A comparison between UHF and acoustic methods	Qi, Bo; Chengrong Li; Zhen Hao; Bibo Geng; Danguo Xu; Shaoyu Liu; Chun Deng	Beijing Key Lab. of High Voltage & EMC, North China Electr. Power Univ., Beijing, China	Electrical Insulation (ISEI), Conference Record of the 2010 IEEE International Symposium on	2010	The widespread application of SF6 gas insulated substations (GIS) in high voltage power transmission requires reliable fault detection and diagnosis techniques. Partial discharge (PD) detection has so far been proven to be the most effective tool for GIS insulation diagnosis. Both ultra high frequency (UHF) technique and acoustic means have been popularly used in PD detection thanks to their well-noted anti-interference performance. In spite of numerous researches on either UHF or acoustic techniques, little has been done to draw a comparison between the two. To address this research gap, the present research simulates five major types of PD discharges caused by the immobilized particles on insulator surface, free metallic particles on insulator surface, protrusion on inner shell, high-voltage electrode faults and floating conductor discharge on a well-established 220kV test assembly, where PD signals were simultaneously detected by both UHF and acoustic methods. The two detection means are compared among the five PD models and different applied voltages in terms of inception voltage for discharge, average apparent discharge magnitude, discharge pulse count and average discharge amplitude. Based on the test results, it is suggested that the UHF method can be used as the major measurement for the diagnosis of insulation degradation in GIS with other necessary means serving as supplementation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5549553



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Mathematical model of influence of oxygen and moisture on feature concentration ratios of SF ₆ Decomposition Products	Fan Liu; Ju Tang; Yilu Liu	State Key Lab. of Power Transm. Equip. & Syst. Security & New Technol., Chongqing Univ., Chongqing, China	Power and Energy Society General Meeting, 2012 IEEE	2012	<p>Partial discharge (PD) is triggered by insulation defects in a gas-insulated switchgear (GIS), leading to the decomposition of SF₆ gas. The decomposition products of SF₆ can be used to detect and recognize PD. Three concentration ratios of SF₆ decomposition products, namely, $c(\text{SO}_2/\text{F}_2)/c(\text{SOF}_2)$, $c(\text{CF}_4)/c(\text{CO}_2)$ and $c(\text{CF}_4 + \text{CO}_2)/c(\text{SO}_2/\text{F}_2 + \text{SOF}_2)$, have been used as feature parameters in PD recognition. However, the values of these concentration ratios are not only related to the type of PD, they are also affected by the oxygen and moisture contents in GIS. In order to improve the performance of PD recognition, it is essential to calibrate the values by the influence rules of oxygen and moisture on feature concentration ratios. In the current paper, an experimental platform was constructed to simulate SF₆ decomposition under PD in a GIS. The concentration data of CF₄, CO₂, SO₂/F₂ and SOF₂ under different moisture contents and oxygen contents were obtained. The data show that the values of $c(\text{SO}_2/\text{F}_2)/c(\text{SOF}_2)$, $c(\text{CF}_4)/c(\text{CO}_2)$ and $c(\text{CF}_4 + \text{CO}_2)/c(\text{SO}_2/\text{F}_2 + \text{SOF}_2)$ decrease with the increase of moisture and oxygen contents. By analysis of chemical dynamic theory, it is found that the influence rules of oxygen and moisture contents on the concentration ratios can be expressed by power function. The mathematical model was then developed by nonlinear regression. The predicting results show that the model has an acceptable performance.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6345421



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Detection and location of PD activities using an array of fiber laser sensors	Kung, P.; Wang, L.; Comanici, M.-I.; Chen, L.R.	QPS Photonics, Pointe Claire, QC, Canada	Electrical Insulation (ISEI), Conference Record of the 2012 IEEE International Symposium on	2012	<p>Partial discharge (PD) measurement has been deployed as a well established test method to monitoring the health of the insulation inside generators, transformers, gas insulated switch gear, and bus bars. There are different technologies to monitor the health of insulation by PD measurement, e.g., UHF high frequency capacitance measurement and acoustic emission using piezoelectric sensors. UHF technique has proven to be very sensitive but had troubles locating the sources of such PD activities. Piezoelectric acoustic sensors seem to be able to locate PDs, but their signal is weak and locating the sources using time of arrival method proves to be complicated: acoustics signal can travel through the insulation media such as oil or SF6, but they could also hit the metallic container and then travel to where the sensor is mounted. This paper will discuss a break through. First, a fiber laser can be formed by including a twin grating structure over an active fiber segment having Erbium and Ytterbium doping and pumped with 980 nm laser light. A DBR laser capable to follow very high frequency response is formed. Furthermore, this cavity can be made to be wavelength specific. A string of these can be installed over the walls of the transformer or a multi-segment GIS or Bus Bar. The signal from these laser sensors will become self identifying. These reflected signals can be demultiplexed with an array waveguide grating (AWG), which places the signal into buckets of various center wavelengths; therefore, each bucket can be related to where the sensor has been installed. The fiber laser sensor gives a higher signal to noise ratio than piezoelectric sensors, and these DBR lasers can be serially connected to diagnose the location of the PD events. There is no need for complicated software and algorithm to calculate and interpret the difference in time of arrival. Furthermore other fiber optics sensors such as temperature, moisture and loading can be installed to help to correlat- PD with these operational and environment condition.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6251522



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
High Voltage Vacuum Interrupters; Technical and Physical Feasibility versus Economical Efficiency	Renz, R.	Siemens AG, Berlin	Discharges and Electrical Insulation in Vacuum, 2006. ISDEIV '06. International Symposium on	2006	<p>In the medium voltage range the vacuum switching principle is well established (Fink and Renz, 2002). Today vacuum circuit breakers are available up to 52 kV rated voltage and 80 kA short-circuit current. By using a series arrangement of two or more vacuum interrupters it is basically possible to double or multiply the dielectric strength without increasing the operating energy substantially. Applications with two 24 kV or 36 kV standard vacuum interrupters in series for rated voltages of 52kV or 72kV are well known. In principle there is no restriction on the medium voltage range for single vacuum interrupters. Tubes for 72kV and even 145kV applications are described by several manufacturers. However due to a nearly square-root dependence between the dielectric strength and the contact stroke it is not trivial to find acceptable solutions. Concerning environmentally aspects also the external insulation of the interrupter causes problems. SF6 is well established in compact gas-insulated switchgears (GTS). Of course designs for air-insulated switchgears (AIS) are possible. But adequate solutions have to be found. Another issue to be considered is the interrupting capability. The dependence on contact stroke for conventional contact systems may limit short circuit current interrupting capability. The higher the stroke the lower the maximum current, which can be properly interrupted. Increasing of the contact diameter ad infinitum is useless. Switching capacitors is the next technical challenge. On one side a dielectric sufficient stroke is necessary, on the other side increasing contact gap reduces the interrupting capability. Overvoltages produced by switching inductances also deserve closer attentions. Common contact materials for medium voltage vacuum interrupters are maybe not suited for low surge behaviour in high voltage devices. Together with the electrical items the mechanical stability of the interrupter has not to be sneezed at. The endurance of the bellows and housing as well as the bending and upsetting of the conduction bolts demand high sophisticated engineering. In spite of all the technical problems proper solutions up to 72kV were developed in the past and 145kV-bottles with a single interrupter gap are possible. The main handicap against the introduction of vacuum technology into the high voltage domain is obviously the economical efficiency. Well established technologies and production facilities enable cost-effective products today. A decision pro vacuum is possible for high voltage applications as recently as technical and commercial solutions are available</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4194861



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Gas insulated substation GIS	Bolin, P.; Koch, H.		Power Engineering Society General Meeting, 2006. IEEE	2006	Reliable and economical power transmission and distribution are key functions for the future electric power supply. Gas insulated switchgear is used in industrial areas to fulfil high-energy demands by space saving design with a minimum of cost. Only SF6 insulated switchgear is able to fulfil these requirements. SF6 switchgear installed in Canada in a 550 kV substation with 100 kA as the highest breaking capacity ever achieved in one of the steps of development since then. Consistent research and development and innovative energy led to the third generation of nowadays compact and overall optimized switchgear. The advantages of gas-insulated switchgear are its compact design and the modular system. The standardized modular structure is made to match the various customers specifications and allows to realize almost all substation configurations in compliance to them	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1709113
Gas insulated substation GIS	Bolin, P.; Koch, H.		Transmission and Distribution Conference and Exposition, 2008. T&D. IEEE/PES	2008	GIS technology is typically of modular design and filled with a minimum of SF6. It has low- LCC cost and can be used for indoor and outdoor application. At these days the GIS technology started based on extensive fundamental research and since then the service experience together with innovative development work has brought this technique forward to a safe and environmental compatible, a most reliable and available element of the energy supply. The tremendous progress of development can be seen as an example of the classic three phase enclosure of a 72.5-170 kV GIS. Reliable and economical power transmission and distribution are key functions for the future electric power supply. High-voltage switchgear and equipment for voltages above 1 kV up to 800 kV are safety elements within the electrical energy supply and therefore subjected to a very high standard of availability and reliability. Gas insulated switchgear is used in industrial areas to fulfill high-energy demands by space saving design with a minimum of cost. Only SF6 insulated switchgear is able to fulfill these requirements.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4517307



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Sustainable performance of Gas-Insulated Switchgear	Glaubitz, P.; Rudenko, P.; Shen Wei; Li Dejun	Power Transm., Siemens AG, Erlangen, Germany	High Voltage Engineering and Application (ICHVE), 2012 International Conference on	2012	Modern Gas Insulated Switchgear (GIS) technology has been undergoing continual development since its introduction in the 1960's when the use of SF6 as arc extinguishing and isolating medium was first introduced, and whilst many may consider this technology as mature, there have been continuous development driven changes in GIS design, manufacture, test and operation. Consistent research and innovative development led to the nowadays compact and overall optimized switchgear. Today, GIS technology consists typically of a modular design and is filled with a minimum of SF6. The standardized structure is made to match various individual customers' specifications and allows realizing almost all substation configurations accordingly. Furthermore, it offers low life cycle costs with reduced maintenance and can be used for indoor and outdoor applications. And above all, green substation aspects are strongly considered.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6357038
Behavior of metallic particles in a single phase gas insulated system with dielectric coated electrodes	Kumar, G.V.N.; Amarnath, J.; Singh, B.P.	Vignan's Inst. of Inf. Technol., Visakhapatnam	Condition Monitoring and Diagnosis, 2008. CMD 2008. International Conference on	2008	The development of compressed gas insulated switchgear (GIS) equipment has progressed rapidly. Conducting particles in transmission and switching equipment insulated by compressed sulphur hexafluoride (SF6) can result in loss of as much as 90% of the gas dielectric strength. These particles may be free to move in the electric field or may be fixed on the conductors, thus enhancing local surface fields. In a horizontal coaxial system with particles resting on the inside surface of the enclosure, the motion of such particles is random but the randomness depends on the coefficient of restitution and angle of incidence when approaching the coaxial conductors. The power industry has utilized several methods to control and minimize the effect of particle contamination in GIS. One such technique is to apply a dielectric (high resistivity) coating to the inside surface of the outer GIS enclosure. The electric field necessary to lift a particle resting on the inside surface of a GIS enclosure is much increased due to the coating. The simulation of the particle movement was carried under different AC voltage levels for coated and uncoated cases. The results have been presented and analyzed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4580305



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Application of dry-air insulating media in 170kV GIS	Madarasz, G.A.; Byung Hwa Choi; Joo-Yeong Lee	Hyundai Technol. Center Hungary, Budapest, Hungary	Electrical Insulation Conference (EIC), 2011	2011	Dry-air is a promising insulating medium for substituting the SF ₆ gas in industrial devices. The lower insulating performance of dry-air was compensated by moderate increase of service pressure and careful optimization of electric field within high voltage gas insulated switchgears (GIS). In addition to the insulating feature the different heat-transport characteristics of dry-air were also considered. The electric field distribution was simulated and compared with impulse test results on a compressed dry-air insulated integrated disconnecter-earthing switch unit. The aim of development was to find a technically and economically optimal solution, which is equivalent to the SF ₆ gas insulated switchgear unit.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5996131
Very Low SF ₆ Insulation Gases for Medium Voltage Switchgear	Moore, J.A.	S&C Electr. Co., Chicago, IL	Power Engineering Society General Meeting, 2007. IEEE	2007	Due to global warming concerns, switchgear with lower global warming potential (GWP) may become desirable. This work investigates using very low (<10%) levels of sulfur hexafluoride (SF ₆) along with common gases for insulating switchgear. Design of experiments (DOE) is used to isolate significant factors and to generate a model, an empirical equation for predictive use. For calculating GWP of gas mixtures, a weighted average calculation is made. Results show that mixtures of 0-5% SF ₆ and carbon dioxide (CO ₂) may be sufficient for 15 kV class equipment, and 3-8.5 % SF ₆ with CO ₂ may be sufficient for 25 kV. In this work, CO ₂ was more effective than nitrogen. Using the weighted average calculation for GWP, these blends compare favorably with the automotive air conditioner refrigerant (R-134a, GWP = 1,300) in common use today. R-134a is approved by international agreement for automotive use to 2030(1). The resulting DOE model proved to have excellent predictive power.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4275341

Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Dielectric Performance of Improved Gas Insulated Bushing for UHV Gis	Hosokawa, Masao; Okumura, Kiyoshi; Yamagiwa, Tokio; Ishikawal, Toshio; Ozawa, Jun	Kokubu Works, Hitachi, Ltd. Hitachi-shi, Japan	Power Delivery, IEEE Transactions on	1987	This paper describes a improved gas insulated bushing for ultra high voltage (UHV) SF6 gas insulated switchgear (GIS) which contains a simple capacitor core inside a porcelain housing. The effects of arrangement and capacitance of the capacitor core on the voltage distribution along the external porcelain surface were analyzed, and a 2/3 scale model of a prototype UHV gas insulated bushing (6.7m porcelain housing) was developed. Characteristics tests of the voltage distribution and dielectric withstand voltage indicated that the voltage distribution was greatly improved and the dielectric withstand voltage of the switching impulse under wet conditions was enhanced about 30% compared with a conventional gas insulated bushing.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4308116
150 KV EPM cable connections between transformers and SF6 insulated switchgear for 5 substations in Rome	Parvopassu, P.; Solimando, F.; Rolandin, L.M.; Occhini, E.	A.C.E.A., Rome, Italy	Power Apparatus and Systems, IEEE Transactions on	1977	The paper describes a particular application of 150 kV EPM cable to provide short connections within substations in Rome. The principal reasons for making this choice are explained, and the construction characteristics of cables and accessories used for connecting transformers to SF6 insulated switchgear are described. The results of calculations to evaluate the reliability of the connections are reported, together with electrical tests on cable and accessories. The experience acquired from this first installation will be used in making a practical evaluation of the reliability of the present connection and will allow its extension in a subsequent phase, to longer lines in more severe ambient conditions.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1601923
Specification and Application of SF6 Compressed Gas Insulated Switchgear A Utility's Point of View	Cuk, N.; Nishikawara, K.K.; McCrae, G. G.; Adams, P. T B	BRITISH COLUMBIA HYDRO & POWER AUTHORITY	Power Apparatus and Systems, IEEE Transactions on	1980	The introduction and application of a new technology, SF6 compressed gas insulated (CGI) switchgear has resuled in some problems not foreseen by the users nor are they adequately provided for in the existing standards for conventional switchgear. This paper discusses the accumulated experience of the B.C. Hydro and Power Authority in the areas of planning, specifications, tender evaluation, testing and operation of 550 kV and 230 kV minisubstations. Particular emphasis is placed on the need for national and international standards specially framed for CGI switchgear and for in-depth knowledge by present and potential users of this equipment.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4114061



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Transient Ground Potential Rise in Gas Insulated Substations - Experimental Studies	Fujimoto, N.; Dick, E. P.; Boggs, S.A.; Ford, G. L.	Research Division Ontario Hydro	Power Apparatus and Systems, IEEE Transactions on	1982	The very rapid dielectric breakdown of SF6 (eg, during the operation of disconnect switches in gas-insulated substations) generates steep-fronted travelling waves which couple to the exterior enclosure surface at the air/SF6 bushings and cause transient ground potential rise. These high voltage transients, which can be in the 100 kV range, propagate from the air/SF6 termination, along a transmission line defined by the bus enclosure and the ground plane, toward the switchgear. This paper presents a theoretical and experimental investigation of the phenomenon, from which the basic mechanisms have been identified.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4111173
Applying a Voice Recognition System for SF6 Gas Insulated Switchgear's Inspection/Maintenance Services	Nakano, S.; Tsubaki, T.; Hironaka, S.	Hitachi Engineering & Services Ltd., Ibaraki-ken, Japan	Power Engineering Review, IEEE	2001	The authors have developed a new set of portable voice recognition systems that are compact, lightweight, and have two-way communication (sending and receiving) for the purpose of inspection/maintenance services for substation equipment. The authors are using these newly developed systems for daily visual inspection, periodic inspection, and commissioning tests of substation equipment. By applying these systems with the added guidance and judgment functions, it is possible for unskilled personnel to carry out inspection/maintenance services of substation equipment. It is possible to feed the data collected at the site directly into the computer, and the trend control management can be done easily. This paper outlines the voice recognition system, the applied examples of SF6 gas insulated switchgear's (GIS) periodical inspection/maintenance, and the achieved results.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4311476



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Characterization of GIS Spacers Exposed to SF6 Decomposition Products	Braun, J-M; Chu, F. Y.; Seethapathy, R.	Ontario Hydro Research Division Toronto, Canada	Electrical Insulation, IEEE Transactions on	1987	SF6 gas-insulated switchgear is a sealed system, but low- level contamination can accumulate and affect spacer performance. The degradation of a number of spacer materials exposed to either direct arcing conditions or arc by-products was investigated to correlate their surface molecular features with changes in electrical performance. Electron Spectroscopy for Chemical Analysis, Scanning Electron Microscopy, Infrared and Thermal Analysis were used to probe the surface of the dielectrics. In the immediate vicinity of the spark, spacer surfaces undergo irreversible chemical, morphological, and physical changes with extensive pyrolysis and surface erosion. There is clear evidence of chemical reactions with high concentrations of fluorine bonded to the organic resin. Exposure of spacer materials to SF6 arcing by-products results in significant reduction in electrical properties with profound changes in the chemical structure of both epoxy moieties and/ or filler particles. This paper will describe the surface characterization techniques as applied to degraded spacer surfaces and discuss the possible degradation mechanisms.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4081387



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Factors dominating dielectric performance of real-size gas insulated system and their measures by dielectric coatings in SF ₆ and potential gases	Hama, H.; Okabe, S.	Mitsubishi Electric Corporation, 8-1-1, Tsukaguchi-Honmachi, Amagasaki, 661-8661, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2013	<p>The paper focuses on the factors that lower the dielectric performances of real-size gas insulated systems, and show the examples of the measures by using dielectric coatings. The factors studied in this paper are area effects of electrodes and metallic particle motion which are now dominant to determine the size of gas insulated switchgear (GIS). The gases for the systems are basically SF₆ but potential gases like N₂/SF₆ gas mixtures, CO₂, dry air and N₂ are also included. Area effects of electrodes are studied by reviewing the minimum breakdown data at lightning impulse (LI) of large effective electrode area over about 5 x 10⁴ mm² under high gas pressures up to 1.9 MPa. The breakdown electric field strength (BDE) or breakdown voltage (BDV) is normalized by the theoretical value and evaluated in terms of effective electrode area and gas pressure. Under the same gas pressure in the range between 0.2 and 0.7 MPa at negative LI, the normalized values of SF₆ are lower than those of the potential gases which show similar values. However, the normalized BDVs of N₂ at positive LI are further lower than those of SF₆ at negative LI. The advanced dielectric coatings enable high dielectric performances over 80% of the theoretical values in SF₆ and CO₂. Concerning the second factor, metallic particle motion, the experimental data of metallic particle levitation and crossing to high voltage electrode are gathered for dielectric coated and bare enclosures in SF₆, N₂/SF₆ and dry air. The data are classified into two cases of with and without mechanical impulsive force to the enclosure, which simulates the force by the operation of circuit breakers, disconnecting switches and earthing switches. The particle lift-off/levitation electric field strength on the inner surface of dielectric coated enclosure is about 2 to 11 times higher than that on bare enclosure without a mechanical vibration. With a mechanical vibration, the particle lift-off/levitation and crossing electric field strength on dielectric coated enclosure decrease but still about 2 to 3.5 times and 1.3 to 1.6 times higher than those on bare enclosure, respectively.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6633704



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Ground Fault by Restriking Surge of SF6 Gas-Insulated Disconnecting Switching and its Synthetic Tests	Nishiwaki, S.; Kanno, Y.; Sato, S.; Haginomori, E.; Yamashita, S.; Yanabu, S.	Toshiba Corporation	Power Apparatus and Systems, IEEE Transactions on	1983	During a breaking operation of charging current with a disconnecting switch (DS) in SF6 gas-insulated switchgear (GIS), the occurrence of a fault to ground from the DS contact by a restriking surge was reported to be observed. The flashover voltage in this case, is appreciably lower than the normal withstand voltage to the ground. It has been clarified through high-speed photography with an image converter camera that the flashover is caused by a streamer generated during restriking between the DS contacts. In this respect, with the objective of confirming these phenomena in a simulated power system, two synthetic test circuits were constructed by using 550kV DS's. Verification tests were carried out to confirm the equivalence between these two test circuits. The DS's subjected to test withstood a surge voltage of 2.3pu-the maximum voltage obtained by simulating calculations of various GIS configurations.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4111811
Package Substation System Type Enk with SF6 Insulation	Wieland, A.; Koglin, B. B.; Leonhardt, G.	BROWN BOVERI AG	Power Apparatus and Systems, IEEE Transactions on	1982	The technical advantages of SF6 gas insulated switchgear are in general well known; however, GIS is mostly used in modular pipe-type designs above 121 kV systems.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4111594
High Current Interruption by SF6 Disconnecting Switches in Gas Insulated Switchgear	Yanabu, S.; Nishiwaki, S.; Mizoguchi, H.; Shimokawara, N.; Murayama, V.	Toshiba Corporation	Power Apparatus and Systems, IEEE Transactions on	1982	In the GIS, the high closed loop current is required to be interrupted by a disconnecting switch. The longer arcing time during an interruption will produce greater amount of decomposite products, and thus will deteriorate an insulating performance. Test was carried out using various kinds of electrode structures with a view to reducing the arcing time. A magnetic driving type or puffer type electrode structure was found to be effective for reducing the arcing time.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4111437



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Design, Simulation, and Testing of an EHV Metal-Enclosed Disconnecter	Lopez-Roldan, J.; Irwin, T.; Nurse, S.; Ebden, C.; Hansson, J.	VA Tech Reyrolle, Hebbum, Tyne & Wear, U. K.	Power Engineering Review, IEEE	2001	One of the most demanding design issues in the development of metal-clad disconnectors for applications at 500 kV and over is to ensure the switching capabilities of the device. This paper presents the issues and processes involved from the initial design through to final testing of a 550 kV disconnector. The initial work concentrated on defining the design parameters in order to minimize the risk of arc breakout. Computer analysis using 2D and 3D modeling of the contact configuration was carried out. As a following step, before building the disconnector the results of the computations were validated by a static test where the electrode arrangement was set manually at different gap distances and discharges between contacts were monitored. From the computational and test data a final contact design was optimized and a disconnector prototype was built. Finally, the capabilities for bus-charging current switching were tested in accordance with the IEC 1259 standard. The results of these tests include measurement and comparison with EMTP simulations of the fast transient over voltages generated by disconnector operations.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4311478
Novel Low-Cost SF6 Arcing Byproduct Detectors for Field Use in Gas-Insulated Switchgear	Braun, J-M; Chu, F. Y.	Ontario Hydro Research Division Toronto, Canada	Power Delivery, IEEE Transactions on	1986	Two low-cost, SF6 arcing byproduct analyzers were developed by Ontario Hydro for field use in GIS. The analyzers are based on widely available detector tube technology and can be used readily by field personnel without extensive training. The highly sensitive analyzers can be used rapidly in-situ (ie. analysis times of about one minute) for diagnostic purposes for both fault location and partial discharge detection. The analyzers were successfully tested on several occasions at Ontario Hydro substations after power arc faults, providing excellent correlation with laboratory results.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4307937

Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Study on switching impulse test waveform for UHV-class electric power equipment	Okabe, S.; Ueta, G.; Tsuboi, T.; Takami, J.	Tokyo Electr. Power Co., Yokohama, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2012	<p>Ultra high voltage (UHV) systems are increasingly being planned and constructed, hence studies are promoted on the standard for high-voltage test techniques for UHV-class equipment, the scope of which includes the switching impulse voltage test waveform. Influences that must be considered to study this test waveform are those of actual switching overvoltage waveforms generated in the UHV system and applied to equipment and the change in the breakdown characteristics associated with a longer insulation length such as an air gap clearance. In the present paper, to determine the switching impulse test waveform, switching overvoltage waveforms applied to the UHV equipment were initially investigated. As a result, it emerged that the time to peak T_p was long, ranging from 700 μs to 1000 μs, for closing overvoltage which is relatively high switching overvoltage. When other types of overvoltage in the switching surge range were considered, the T_p varied widely from 100 μs to 1000 μs. Subsequently, the insulation characteristics of UHV-class long air gaps for switching impulse waveforms were investigated. It emerged that, for the fundamental model, namely rod-plane electrodes, the T_p of switching impulse waveforms with the lowest breakdown voltage (critical time to peak, T_{cr}) ranged from 350 μs to 550 μs whereas it shifted to a shorter time of 200 μs to 350 μs when environmental conditions, such as humidity and precipitation, were taken into consideration. For basic structure models assuming actual facilities and real scale structure models, the T_{cr} ranged from 100 μs to 300 μs. Furthermore, the internal insulation characteristics for switching impulse waveforms, such as SF₆ gas and oil-paper insulation, were also investigated. Consequently, in the case of the internal insulation of equipment such as gas insulated switchgears (GIS) and transformers, the T_p of switching impulse waveforms had a minor influence on the insulation characteristics, even if it varied from 100 μs to 1000 μs. Following comprehensive evaluation of these characteristics, it was concluded that, in the switching impulse test for UHV-class equipment, it is reasonable to apply a waveform of 250/2500 μs, which is the same as that for equipment of 800 kV or less.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6215082



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Surface charge accumulation and partial discharge activity for small gaps of electrode/epoxy interface in SF_6 gas	Mansour, D.-E.A.; Kojima, H.; Hayakawa, N.; Endo, F.; Okubo, H.	Dept. of Electr. Eng. & Comput. Sci., Nagoya Univ. Furo-cho, Nagoya, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2009	The electrical insulation reliability of solid spacers in gas insulated switchgears (GISs) is an important issue to achieve a safe operation of such equipment. Among different phenomena, charge accumulation represents the most important matter that can degrade the overall performance of these insulation systems. For this respect, this paper discusses the contribution of partial discharge (PD) activity by ac voltage application to charge accumulation in the small gap at the electrode/epoxy interface as one of the weakest points in GIS solid spacers. The partial discharge inception voltages for non-accumulated charge case (PDIV_{0}) and after exposing to PD activity (PDIV_n) are measured among different gap lengths, simulating delamination at the electrode/epoxy interface. The PD activity is generated using applied voltage with $1.2\text{f}\hat{A}\text{---}\text{PDIV}_{0}$ for all gap lengths examined in this study (50~500 $\hat{A}, \hat{A}_2\text{m}$). In these measurements, PDIV increased with increasing the number of PD pulses as a result of accumulated charges. The accumulated surface charge density is estimated using the boundary equations and is compared for the different gap lengths. The accumulated charge density was larger for the smaller gap lengths. Comparing PD parameters with accumulated charge density enabled us to identify that the number of negative and positive PD pulses is the main parameter that corresponds to charge accumulation process.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5211869



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
State of the art GIS technology and trends	Rudenko, P.; Wallner, C.; Behne, M.	Siemens AG, Erlangen, Germany	Transmission and Distribution Conference and Exposition (T&D), 2012 IEEE PES	2012	Modern gas insulated switchgears (GIS) technology has undergone continuous development since its introduction in the 1960's, when the use of sulphur-hexafluoride (SF6) gas was first introduced as an insulating and arc extinguishing medium. With the use of SF6, the world's first high voltage gas insulated switchgear was introduced into the market in 1968. Whilst many may consider this technology as mature, there have been continuous development-driven changes in GIS design, manufacture, test and operation. Consistent research and innovative development led to the nowadays compact and overall optimized switchgear. Today, GIS technology consists typically of a modular design and is filled with a minimum of SF6. The standardized structure is made to match various customers' specifications and allows realizing almost all substation configurations accordingly. Furthermore, it offers low life cycle costs and can be used for indoor and outdoor applications. What trends have shaped the GIS of today, and which will determine how GIS will further evolve into the future in terms of design, manufacture, test, and operation throughout its life cycle? What are the customers' visions and what are the manufacturers' answers?	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6281403



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Partial discharge recognition through an analysis of SF ₆ decomposition products part 1: decomposition characteristics of SF ₆ under four different partial discharges	Ju Tang; Fan Liu; Xiaoxing Zhang; Qinghong Meng; Jiabin Zhou	State Key Lab. of Power Transm. Equip. & Syst. Security & New Technol., Chongqing Univ. Chongqing, China	Dielectrics and Electrical Insulation, IEEE Transactions on	2012	<p>Partial discharge (PD) is usually aroused before the failure of gas insulated switchgear (GIS) caused by defects, which results in the decomposition of the SF₆ used as insulating gas. Analyzing SF₆ decomposition products can aid in PD detection. Before recognizing PD types by analyzing SF₆ decomposition products, the decomposition characteristics of SF₆ under different types of PD should be investigated first. In this paper, a gas chamber and four typical types of artificial defects were designed to simulate the SF₆ decomposition phenomenon under PD in GIS. A gas chromatography system was established to detect SF₆ decomposition products. By selecting the chromatographic column, SF₆ decomposition products were successfully separated and their concentrations were measured. Numerous SF₆ decomposition experiments under four kinds of PD generated by four kinds of artificial defects were carried out and the SF₆ decomposition products produced by each experiment were detected. The decomposition characteristics of SF₆ under the four defects were different in terms of decomposition amount, generation rate, and concentration ratio, among others. It is feasible to recognize the type of PD by analyzing SF₆ decomposition products.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6148499



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Breakdown mechanism in C ₃ F ₈ /CO ₂ gas mixture under non-uniform field on the basis of partial discharge properties	Hikita, M.; Ohtsuka, S.; Okabe, S.; Ueta, G.	Dept. of Electr. Eng., Kyushu Inst. of Technol., Kitakyushu, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2009	This paper investigates simultaneous measurements of partial discharge (PD) current and the corresponding light emission phenomena of C ₃ F ₈ /CO ₂ gas mixture under a non-uniform field with AC high voltage application in order to discuss the PD properties and breakdown mechanism of new gaseous dielectrics as SF ₆ substitutes. Perfluoro carbon (PFC) gas mixture is a possible candidate as SF ₆ substitute because it almost fulfills the environmental aspects, dielectric properties, boiling point, and other requirements of SF ₆ substitute. The authors simultaneously measured PD phenomena such as time-sequential PD current pulses and corresponding light emission images before breakdown during the positive half cycle of the applied AC voltage where most breakdowns occurred. Consequently, it was found that there were three kinds of current pulse patterns, which depended on the gas pressure and the applied voltage amplitude. It was also confirmed that breakdown occurred around the voltage peak, i.e. 90 degrees of the applied voltage, irrespective of the PD pattern. Furthermore, the simultaneous measurements enabled the authors to classify the discharge area in the N-shaped characteristic of the breakdown voltage based on discrimination of discharge types between streamer and leader discharges. Namely, the location where leader discharge is generated by the transition from streamer discharge in the N-shaped characteristic was indicated. These experimental results and the simultaneous measurement technique will help clarify the breakdown mechanism for new gases or gas mixtures as SF ₆ substitutes. The obtained results will also contribute to insulation diagnosis for next-generation gas-insulated power apparatus with the newly developed gaseous dielectrics.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5293955

Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Spacer flashover characteristics in SF ₆ under repetitive nanosecond-pulses	Huijuan Ran; Jue Wang; Tao Wang; Yaohong Sun; Dongdong Zhang; Ping Yan	Inst. of Electr. Eng., Beijing, China	Power Modulator and High Voltage Conference (IPMHVC), 2012 IEEE International	2012	Very Fast Transient Overvoltages (VFTO) might result in insulation failures inside or outside Gas Insulated Switchgears (GIS), and most of them are led to by the spacer flashovers in the light of operational experiences. To get a better understanding of the discharge process, an experimental study on spacer flashovers under nanosecond-pulses in compressed Sulphur Hexafluoride (SF ₆) gases is presented. A solid-state pulse generator, SPG200N, is used to generate nanosecond-pulses with a rise time of 15 ns and a full width at half maximum of 30-40 ns. The pulse repetition frequency (PRF) varies from 1 Hz to 1 kHz. The material of spacer is epoxy resin, a common material as insulators in GIS. The test electrodes are brass parallel-plane electrodes, 80 mm in diameter, to simulate uniform field in GIS. In this research, the relations of flashover time lag with gas pressure and PRF are investigated. The experimental results show that the flashover time lag gradually rose with the increase of gas pressure under single shot and lower PRF.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6518771
Spacer flashover characteristics in SF ₆ under repetitive nanosecond pulses	Huijuan Ran; Jue Wang; Tao Wang; Cheng Zhang; Ping Yan; Lei Wang	Key Lab. of Power Electron. & Electr. Drives, Inst. of Electr. Eng., Beijing, China	Dielectrics and Electrical Insulation, IEEE Transactions on	2013	Very fast transient overvoltages (VFTO) may result in insulation failures inside or outside gas insulated switchgears (GIS), and most of them are caused by surface flashovers along insulating spacers according to operational experiences. For a good understanding of the discharge process produced by high voltage pulses with a fast rising time, an experimental study on spacer flashover under repetitive nanosecond pulses in high pressure sulphur hexafluoride (SF ₆) is presented. A solid-state pulse generator is used to generate nanosecond pulses with a rise time of 15 ns and a full width at half maximum of 30~40 ns. The pulse repetition frequency (PRF) varies from single shot to 1 kHz. Brass parallel-plane electrodes and cylinder epoxy resin spacer are used to represent a configuration of uniform electric field and insulator in GIS, respectively. In this experiment, the parameters of amplitude of discharge current, flashover time lag and number of applied pulses to flashover are investigated. And their relationships with gas pressure and PRF are analyzed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6571431



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Coupled simulation of gas flow and dynamic analysis for stroke calculation in circuit breaker	Lee, Y. S.; Ahn, H.S.; Park, S. W.; Lee, J.H.	LS Ind. Syst., Cheongju, South Korea	Electric Power Equipment - Switching Technology (ICEPE-ST), 2011 1st International Conference on	2011	Electrical energy transmission and distribution devices are becoming more sophisticated and diversified in design, and also higher in its capacity due to rising in electricity usage. In direct response to demands of more reliable GIS (Gas Insulated Switchgear) from customers, computer simulations such as dynamics, structural, and fluid dynamics analysis are becoming more incorporated into the design process. Among the many types of simulations in GIS are low current interruption, SLF interruption, and BTF interruption. In the simulations, a stroke profile measured under loaded condition is required, and it leads to reduction in time and cost required towards the product development. In the paper, first, the actuator and interrupter of GIS is modeled using dynamics simulation program called RecurDyn. Second, SF6 gas pressure change in the interrupting chamber is made into a sub-routine using house code. Finally, with consideration of ODP (Oil Dash Pot) and friction forces of actuator, stroke profile under actual loaded condition is calculated.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6122969

Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Study on PD detection in SF ₆ using multi-wall carbon nanotube films sensor	Xiao-xing Zhang; Wang-ting Liu; Ju Tang; Peng Xiao	State Key Lab. of Transm. & Distrib. Equip. & Power Syst. Safety & New Technol., Chongqing Univ., Chongqing, China	Dielectrics and Electrical Insulation, IEEE Transactions on	2010	The detection of partial discharge (PD) and the analysis of SF ₆ gas components in gas insulated switchgear (GIS) have great significance for the fault diagnosis and running state assessment of power equipments. In this paper, a method of detecting SF ₆ decomposition components caused by PD is proposed. Accordingly, multi-wall carbon nanotube (MWNT) films sensors which is used to detect PD of SF ₆ is developed. By adopting a kind of chemical modification with concentrated sulfuric acid and nitric acid, the functional modification to carbon nanotubes (CNTs) was realized, as well as transmission electron microscope (TEM) and infrared spectrum analysis of the CNTs both before and after the modification. The test was conducted for MWNTs films sensor in the laboratory using SF ₆ gas PD decomposition component testing device. Test results show that, the MWNTs films sensor has many defects and active functional groups and with strong absorption capacity for SF ₆ decomposition components; it shows good sensitivity and fast response characteristics, and can reflect the overall state of gas decomposition components.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5492256
New Short-Circuit Testing Facilities to Cope With the Recent Development of GIS	Yamamoto, M.; Yamashita, S.; Ikeda, H.; Yanabu, S.	Toshiba Corporation	Power Apparatus and Systems, IEEE Transactions on	1985	Short-circuit testing facilities are discussed for SF ₆ gas-insulated switchgear (GIS) equipment. It is shown that the supply voltage of 28kV will suffice to supply short-circuit current up to 80kA without severe distortions for four breaks used in the full voltage test of a tank-type SF ₆ gas circuit breaker (GCB). A new testing method using two transformers is proposed for a three-phase-in-one-tank-type GCB.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4112912



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Partial discharge recognition through an analysis of SF ₆ decomposition products part 2: feature extraction and decision tree-based pattern recognition	Ju Tang; Fan Liu; Qinghong Meng; Xiaoxing Zhang; Jiagui Tao	State Key Lab. of Power Transm. Equip. & Syst. Security, Chongqing Univ., Chongqing, China	Dielectrics and Electrical Insulation, IEEE Transactions on	2012	<p>The decomposition characteristics of the SF₆ under the different kinds of partial discharges (PD) should be understood first when recognizing PD by analyzing SF₆ decomposition products in gas insulated switchgear (GIS). Moreover, the characteristic quantities used for recognition must be found. In this paper, the concentration and concentration ratio of SF₆ decomposition products were each selected as characteristic quantities. Fuzzy c-means clustering algorithm was adopted to assess the performance of the two types of characteristic quantities, which was based on the data of SF₆ decomposition products under the four kinds of PD in Part 1. Concentration ratio had better performance than concentration as a characteristic quantity in PD recognition. The concentration ratio method for PD recognition was established based on the decision tree theory, in which the three concentration ratios, namely $c(\text{SO}_2)/c(\text{SO}_2\text{F}_2)$, $c(\text{CF}_4)/c(\text{CO}_2)$, and $c(\text{SO}_2 + \text{SO}_2\text{F}_2)/c(\text{CO}_2 + \text{CF}_4)$, were used as characteristic quantities. The physical significance of the three concentration ratios was also analyzed. Finally, the concentration ratio method was applied to test the performance of PD recognition. The method has a good performance and can successfully recognize different kinds of PD.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6148500



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Design and operation perspective of a British UHV laboratory	Ryan, H.M.; Whiskard, J.	Sunderland Polytechnic, Department of Electrical, Electronic and Control Engineering, Sunderland, UK	Physical Science, Measurement and Instrumentation, Management and Education - Reviews, IEE Proceedings A	1986	<p>The authors have, in the past, been directly involved in the design, planning and supervision of the construction, of a new ultra-high-voltage laboratory. The main purpose of the laboratory was to provide a major facility in the UK for the development of switchgear rated up to 765 kV and in the dielectric research required for such an undertaking. Following the opening of the laboratory in 1970, the author have in recent years been closely connected in the development of new ranges of open terminal and metalclad SF6 switchgear rated up to 525 kV and for fault currents up to 63 kA. These activities have been supported by extensive dielectric research studies, which have enabled the major factors influencing the insulation integrity of practical equipment to be determined. First, this paper outlines the criteria used in designing the laboratory and presents a critical appraisal of the facilities during the first 15 years of operation. Secondly, consideration is given to illustrating some significant laboratory activities. Examples are given of various switchgear and nonswitchgear components for systems $\bar{A}, \bar{A}_{\bar{2}}765$ kV, which have been subjected to rigorous dielectric proving tests in the main test hall. The use of specific high-voltage test procedures (e.g. climatic, artificial rainfall, mixed voltage testing) are described, and important technical factors which have influenced the dielectric design of apparatus are considered.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4647847



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
SF6 Decomposition in Gas-Insulated Equipment	Chu, F. Y.	Ontario Hydro Research Division, Toronto, Canada	Electrical Insulation, IEEE Transactions on	1986	<p>The increasing application of SF6 as an insulating gas has led to many studies on SF6 decomposition in gas-insulated equipment. In the presence-of an electric arc, spark or corona, SF6 decomposes to a wide variety of chemically active products which possess completely different properties from SF6. The accumulation of these decomposition products in the equipment has caused concerns regarding personnel safety and material compatibility problems. This paper reviews previous research in SF6 decomposition relating to the operation of gas-insulated switchgears, gas-insulated transmission lines, and electrostatic accelerators. Results on the qualitative and quantitative determination of the by-products and their formation ion rates in various modes of electrical discharges are summarized. The mechanisms leading to the formation of transient and stable products are described. In particular, the influence of discharge energies and impurities on the formation of SOF2 and SO2F2, the two dominant stable by-products, is discussed. The effects of the by-products on personnel safety and equipment ent dielectric integrity are presented. The application of SF6 gas analysis as a tool for diagnosing the internal condition of gas-insulated equipment is assessed. Based on the results of many phenomenological observations, future research activities are suggested to address the issues of safety, compatibility and equipment aging. More fundamental studies on electron, ion, and neutral reaction rates in an SF6 discharge are required to gain a better understanding of the decompositon mechanisms and the influence of the products on equipment operation.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4157059



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Dielectric Behavior of Compact Design Three Phase Coated Gas Insulated Busduct with Metallic Particle Contamination	Padmavathi, D.; Kumar, G.V.N.; Amarnath, J.; Chowdary, D.D.	JB Inst. of Eng. & Technol., Hyderabad	High Voltage Engineering and Application, 2008. ICHVE 2008. International Conference on	2008	<p>The use of a gaseous medium with higher dielectric strength like sulphur hexafluoride (SF₆) instead of air helps in manifold reduction in the size of the sub-station component. Compact GIS systems are essentially three-phase common systems with more than one functional element in one enclosure. Metallic particles can be either free to move in the GIS or they may be tuck either to an energized electrode or to an insulator surface. If a metallic particle crosses the gap and comes into contact with the inner electrode or if a metallic particle adheres to the inner conductor, the particle will act as a protrusion on the surface of the electrode, and the voltage required for breakdown of the GIS will also cause a significant reduction of the breakdown voltage. One method of conducting particle control and deactivation is by coating the inner surface of the outer enclosure. To determine the particle trajectories in a three-phase common enclosure gas insulated busduct (GIB) an outer enclosure of diameter 500 mm and inner conductors of diameters 64 mm spaced equilaterally are considered. Aluminum, copper and silver particles were considered to be present on enclosure surface. Simulation of particle movement with reduced phase conductor is also carried out with a view to obtain optimum size of conductor for reliable operation by reducing the original diameter of the conductor from 64 mm to 54 mm in steps of 5 mm.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4773957



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Situation and analysis of sulfur hexafluoride (SF ₆) byproducts of gas insulated switchgear (220kV and above) in Guangdong Province and latent fault judgment of the electric equipment	Yu Wang; Zhi Li; Weijian Yao; Xiansheng Zhuang; Chengji Huang	Electr. Power Test Res. Inst., Guangdong Power Grid Co., Guangzhou, China	Electricity Distribution, 2008. CIGRE 2008. China International Conference on	2008	In the occurrence of arcs discharges, spark discharges and corona discharges, sulfur hexafluoride (SF ₆) would be decomposed to complicated byproducts such as sulfur dioxide (SO ₂), carbon tetrafluoride (CF ₄), etc. Analyzing the concentrations of these byproducts, which can be determined when the electric equipment is electriferous, is an effective method to judge the internal condition of GIS. The fault of GIS and the position of the fault can be known by SF ₆ byproducts analysis. There are many cases about how to judge the electric equipment faults by analyzing SF ₆ byproducts, but with little experience about how to judge the latent faults. The article concluded the concentrations of SF ₆ byproducts in 74 220 kV and 500 kV GIS transformer substation (3770 gas chambers in total) in Guangdong province. The concentrations of carbon dioxide (CO ₂), CF ₄ , thionyl sulfide (SOF ₂), sulfur fluoride (SO ₂ F ₂), disulfuryl decafluoride (S ₂ OF ₁₀), SO ₂ and sulfureted hydrogen (H ₂ S) were in partial normal distribution. The concentrations of CO ₂ , CF ₄ , SOF ₂ , SO ₂ F ₂ , S ₂ OF ₁₀ were all below 0.1% (v/v); the concentrations of SO ₂ were below 3μL/L; the concentrations of H ₂ S were below 1μL/L. The SF ₆ byproducts concentrations in 500 kV GIS were lower than those in 220 kV GIS. The SF ₆ byproducts concentrations were higher in GIS that have been operating longer.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5211699



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Movement of Metallic Particles in Gas Insulated Line Using SF ₆ and N ₂ Gas Mixture under the Influence of Power Frequency and Switching Transient Voltage	Poonam Upadhyay; Amernath, J.; Singh, B.P.; Upadhyay, P.	Dept. of EEE, VNR Vignan Jyothi Inst. of Eng. & Technol., Hyderabad	Electrical Insulation and Dielectric Phenomena, 2006 IEEE Conference on	2006	This paper presents the particle trajectories in an isolated gas insulated line in SF ₆ -N ₂ gas mixture environment under the influence of power frequency and switching transient voltage. Copper is considered as wire type conducting particle floating in a GIL of 0.1 mm radius and 10 mm of length. The results are shown for movement of particle in different concentration of SF ₆ -N ₂ gas mixture.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4105424
Negative DC Flashover of PTFE and PE Insulators in SF ₆	Zhijie Jia; Hongbo Chen; Jing Li; Wei Xiao; Jin Luo	High Voltage Technol. Dept., Sichuan Electr. Power Res. Inst., Chengdu, China	Power and Energy Engineering Conference (APPEEC), 2012 Asia-Pacific	2012	With the extensive application of high voltage power transformation and distribution apparatus such as GIS and GIL, the dielectric strength of interior supporting insulators become an important factor for equipments' safe and stable operation. In this paper, the cone-plane electrode assembly has been built to simulate the electric field distribution of the coaxial cylindrical configuration in GIS/GIL. Key factors that affect PTFE and PE insulators' flashover characteristics in SF ₆ under DC voltage are investigated mainly from the view of the insulator's surface roughness and metal particles. Results show that the surface dielectric strength of umbrella insulators with smooth surface is fine whether the insulator is made of PTFE or PE. Moreover, whatever the metal particle adhered to insulator surface is near high voltage conductor or grounded enclosure, flashover voltages of the insulator are the lowest under relatively high pressures (≈0.3MPa) if the metal particle is positively charged.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6307285
Progress and experience on type and field testing procedures of SF ₆ gas insulated substations	Aldrovandi, G.; Bonfanti, I.; Figni, E.; Giornelli, F.; Koltunowicz, W.; Li Kai Shing	CESI, Milan, Italy	Power System Technology, 1998. Proceedings. POWERCON '98. 1998 International Conference on	1998	The paper, reports the experience of CESI in the type and field testing of gas insulated substations. For laboratory testing, the paper limits itself to the dielectric and switching performance of switching devices ranging from 145 to 800 kV. Full pole and unit testing together with direct and synthetic testing methods are presented. For field testing, experience in the application of different diagnostic methods during onsite tests and in-service is described	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=728951

Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Partial Discharge Detection Techniques under the Condition of Metallic Particle Adhering to Solid Spacer in SF ₆	Okubo, H.; Nishizawa, K.; Okusu, T.; Hayakawa, N.; Endo, F.; Yoshida, M.; Uchida, K.	Nagoya Univ., Nagoya	Electrical Insulation and Dielectric Phenomena, 2008. CEIDP 2008. Annual Report Conference on	2008	Among the insulation defects in GIS under the operating condition, metallic particles adhered to the solid spacer would be the most critical situation against the surge voltage applications. Nevertheless, because of the complicated partial discharge (PD) mechanisms, PD detection can be recognized very difficult in GIS diagnostic techniques. In this paper, we have successfully simulated the condition of particle adhering on the spacer surface by an experiment applying an AC sudden step voltage. We firstly measured the time dependent PD characteristics, from immediately after the attachment of the particle, by using PD-CPWA (partial discharge current pulse waveform analysis) technique. The PD activities at the particle tip have different characteristics depending on the particle length and the diameter, as well as the gas pressure. Next, we have discussed that depending on the particle conditions, the PD characteristics can be changed with time and with AC half cycle of the polarity and have different sensitivity. Therefore, we need to identify the assessment criteria of GIS, based on the above mentioned phenomena and the facts. Finally, from analyses of PD mechanisms, we proposed the optimum PD detection techniques for adhering particles on solid spacer in GIS.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4772822
Partial discharge activity in gas-insulated system under composite voltage	Sarathi, R.; Dubey, V.; Srinivasa, Y. G.	Dept. of Electr. Eng., Indian Inst. of Technol. Madras, Chennai, India	Power Delivery, IEEE Transactions on	2006	In the present study, the partial-discharge activity under nonstandard voltage formed by ac and dc voltages was studied. It is identified that the ac superposed with positive dc enhances the discharge activity in the medium and if the ac voltage is superposed with the negative dc, it can mitigate the discharge activity. The acoustic emission signal generated due to the partial discharges in gas-insulated systems under the composite voltage formed by ac superposed with dc voltage/ac/dc voltages, has a dominant frequency content at around 250 kHz.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1564237



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
IEEE Draft Guide for Moisture Measurement and Control in SF ₆ Gas-Insulated Equipment			IEEE PC37.122.5/D8, May 2013	2013	Guidelines for moisture level measurement, moisture data interpretation, and moisture control in gas-insulated switchgear (GIS) are provided	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6542632
Discrimination of partial discharge signal in Gas insulated switchgear from external noise using internal signal processing method	Seung Chan Oh; Hyo Sung Lee; Heung-Ho Lee; Seung Min Lee	Electr. Eng., ChungNam Univ., Daejeon, South Korea	Power Modulator and High Voltage Conference (IPMHVC), 2010 IEEE International	2010	GIS (Gas insulated switching gear) is the power equipment with excellent dielectric strength and with economical value in high confidence and stability. Recently the reliability of GIS equipment has been questioned for its long usage, and the importance of the partial discharge on-line diagnosis system has been recognized. A partial discharge (PD) detection system is an effective means for the monitoring and evaluating the dielectric condition of Gas Insulated switchgear (GIS). The ultra-high frequency (UHF) PD detection technique can detect and locate PD sources from the inside of GIS by detecting electromagnetic wave emitted from the PD source. Therefore, a real-time diagnostic system using UHF detection method was developed for this application. However, the signal of partial discharge occurring in SF ₆ gas is very weak and susceptible to external noises which mainly consist of PD in the air. Thus, it is very important to distinguish signal from the external noise signals. Unfortunately, these external noise signals and the partial discharge signals have very similar characteristics. For this reason, the external noise signal is not easy to remove. Therefore to solve this problem, we need the signal processing method to distinguish partial discharge signals from the external noise signals for the improvement of signal to noise ratio (SNR) and sensitivity. In this paper, we proposed the internal signal processing method to remove the external noise signals with built-in preamplifier and frequency conversion circuit.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5958410



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
IEEE Approved Draft Guide for Moisture Measurement and Control in SF6 Gas-Insulated Equipment			IEEE PC37.122.5/D8, May 2013	2014	Guidelines for moisture level measurement, moisture data interpretation, and moisture control in gas-insulated switchgear (GIS) are provided	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6654236
Situation and Analysis of Sulfur Hexafluoride (SF6) Byproducts of Gas Insulated Switchgear in Guangdong	Qiang Fu; Yu Wang; Zhi Li; Weijian Yao; Xiansheng Zhuang	Dept. of Environment & Chem., Guangdong Power Grid Electr. Power Sci. & Res. Inst., Guangzhou, China	Power and Energy Engineering Conference (APPEEC), 2010 Asia-Pacific	2010	The article concluded the concentrations of SF6 byproducts in 74 220 kV and 500 kV GIS transformer substation (3770 gas chambers in total) in Guangdong Province. The concentrations of carbon dioxide (CO2), CF4, thionyl sulfide (SOF2), sulfuryl fluoride (SO2F2), disulfuryl decafluoride (S2OF10), SO2 and sulfureted hydrogen (H2S) were in partial normal distribution.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5449364
Overvoltage protection of gas-insulated substations	Simms, J.R.	GEC Switchgear Ltd., High Voltage Division, Transmission Design Engineering, Manchester, UK	Power Engineering Journal	1987	Increasing demand for electrical power in centres of large conurbations has led to the development of compact gasinsulated substations. For these it is not possible to follow established practice of fitting co-ordination gaps, and therefore surge arresters have to be used to limit overvoltages	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4807747



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Gas insulated switchgear developed to meet increased load demand in Los Angeles Basin	Withers, B.; Bolin, P.; Nakauchi, S.; Shimizu, Y.; Sadakuni, H.; Osumi, M.; Fitzgerald, P.; Flood, J.; Hand, C.L.; Gowhari, D.; Thuan Tran; Dow, D.; Thanh Ninh	Mitsubishi Electr. Power Products, Inc., Warrendale, PA, USA	Transmission and Distribution Conference and Exposition, 2010 IEEE PES	2010	Southern California Edison (SCE) energized the Rancho Vista gas insulated substation (GIS) on May 29, 2009. The substation uses a breaker-and-a-half scheme rated 63 kA at 550 kV and 80 kA at 245kV. The main buses at each voltage are rated 7,500 A continuous. The 500/230 kV substation was built to satisfy rapid load growth and increased reliability requirements for the northeastern Los Angeles Basin.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5484709
Modular online condition monitoring system for gas insulated switchgear	Heinemann, L.; Glock, J.; Rehers, C.; Schulz, T.	ABB AG, Mannheim, Germany	Transmission and Distribution Conference and Exposition, 2010 IEEE PES	2010	The modular online condition monitoring system presented was originally developed for three phase gas insulated substations but can be adapted to other types of switchgear. This system is an add-on component for switchgear with single pole and three pole operated circuit breakers suitable for various layouts which are independent of existing control and protection technology. In addition, the modular online condition monitoring system can be retrofitted on existing installations. Depending on customer needs, the modular system provides the functions requested from simple and cost efficient gas monitoring, up to a complete system with partial discharge detection and arc detection. The online condition monitoring system improves the availability of the complete switchgear and supports maintenance planning by calculation of trends and remaining life reserve of the switchgear components. Communication between devices is based on the communication protocol IEC 61850.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5484322



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Improving the accuracy of SF ₆ leakage detection for high voltage switchgear	Graber, L.	Center for Adv. Power Syst., Florida State Univ., Tallahassee, FL, USA	Dielectrics and Electrical Insulation, IEEE Transactions on	2011	Even though average leakage rates of SF ₆ in high voltage equipment are very low, there is no guarantee for a 100% leakage-free system, especially when considering the generally long lifespan of high-voltage equipment. Taking in view the rather strict maximum allowed leakage rate of SF ₆ per year, regulated by international standards, these facilities should be equipped with suitable monitoring devices. However, accurate detection of low rates of gas leakage is not an easy task. This paper sheds light on the challenges of leakage detection by thorough analysis of physical aspects. Furthermore, it proposes two methods for high-fidelity leakage monitoring and detection with special emphasis on their suitability for use in substations. Application of these methods in the laboratory environment revealed an accuracy of detection levels of 0.3% per year. This is a substantial improvement from the present monitoring systems that show fluctuation levels of the indicator to be as high as up to several percent, which is clearly above the acceptable level.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6118621
Testing of Gas Insulated Substations and Transmission Systems	Graybill, H.W.; Cronin, J.C.; Field, E. J.	Imperial Corporation	Power Apparatus and Systems, IEEE Transactions on	1974	This paper discusses those tests believed necessary in both factory and field to assure safe and reliable performance in a sulphur hexafluoride (SF ₆) gas insulated system. Design tests on prototype components, routine factory production tests and field tests immediately prior to placing the system in service are discussed. Primary emphasis is given to dielectric testing, because of the importance of dielectric considerations to system integrity. Actual test experience on five installations now in service is discussed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4075368



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Investigation of Dielectric Flashover in an SF ₆ Filled Laser Triggered Gas Switch	Benwell, A.; Kovalski, S.; Gahl, J.; Curry, R.; Yeckel, C.; Swarts, D.	Dept. of Electr. & Comput. Eng., Missouri Univ., Columbia, MO	Power Modulator Symposium, 2006. Conference Record of the 2006 Twenty-Seventh International	2006	A study of dielectric flashover in SF ₆ in a laser triggered gas switch (LTGS) is reported. Flashover occurring on the inside of the insulating barrier of the switch leading to the eventual failure of the switch was studied. The University of Missouri-terawatt test stand is testing the trigger section of a LTGS to understand and improve the flashover characteristics of these switches. A Rimfire LTGS was modified to operate with a trigger gap voltage of 938 kV. The modified switch was tested repeatedly over a range of pressures to examine the sensitivity of switch flashover to several parameters. The aspects of the switch that were tested include triple points both due to asymmetrical torque on the endplates, and due to gaps between the insulator and endplate, and the effect of slower voltage risetime. An analysis of the early findings of this study is presented	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4216164
SF ₆ Gas Insulated Load Interrupting Switches With Fusing	Schaffer, J.S.; Patel, J. R.; Rueth, W. R.	G&W ELECTRIC COMPANY	Power Apparatus and Systems, IEEE Transactions on	1984	This paper discusses the design and testing of an SF ₆ , gas insulated load interrupting switch which has multiposition capability. The multiposition capability is achieved through the use of rotary switching contacts which allow a wide variety of switching arrangements within one enclosure.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4112482
Gas Mixtures Insulation Properties Measurements Practical Significance For Switches With Gas Insulators	Osmokrovid, P.; Ljevak, M.; Novakovid, D.; Krstic, S.		Pulsed Power Conference, 1991. Digest of Technical Papers. Eighth IEEE International	1991	This paper presents considerations on the synergistic effects in gas mixtures; the SF ₆ -N ₂ and SF ₆ -Ar, in respect to relevant characteristics of gas insulation. In the experiments we tested following gas properties: dielectric strength, voltage breakdown rate of rise, surface breakdown per insulator within a gas atmosphere. In the experiments we applied: DC and pulse shaped (both polarities), AC and several combinations of DC and pulse shaped voltages. The reversibility of dielectric properties was determined using high current breakdown between two successive measurements. The results obtained were treated statistically by applying theoretical statistic distributions and the U-test to determine the reversibility of dielectric magnitudes. Results shown in this paper have practical significance in obtaining voltage shapes of high speed and manipulation with switching elements based on gas insulators under pressure.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=733298



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
The influence of parallel capacitor and shielding electrode on the electric field of extra high voltage SF ₆ circuit breaker	Xiaoming Liu; Jibin Wen; Yunxue Zhao; Yundong Cao	Sch. of Electr. Eng., Shenyang Univ. of Technol., Shenyang	Automation Congress, 2008. WAC 2008. World	2008	A 3D electric field mathematical model of the arc-quenching chamber in an 800 kV 2-break extra high voltage SF ₆ circuit breaker (EHV SF ₆ CB) has been established and the finite element method (FEM) has been applied to calculate the electric field in the arc-quenching chamber. In computing, multi-dielectrics (such as: air, porcelain casing, PTFE nozzle, SF ₆ gas) have been taken into consideration. And the effect of the parallel capacitor and the shielding covers on the electric field distribution and insulation performance has been studied and analyzed based on the numerical simulation during the dynamic interruption course. Moreover, the electric field strength variations under movable arcing contact and stationary arcing contact in different operating instants are obtained. Consequently, the whole electric field distribution in the arc-quenching chamber with different opening strokes is computed and figured out dynamically.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4699094
Improved Dielectric Strength of SF ₆ Gas with a Trichlorotrifluoroethane Vapor Additive	Qui, Y.; Sun, A.; Kuffel, E.	Xi'an Jiaotong University China	Electrical Insulation, IEEE Transactions on	1987	This paper presents a new approach to improvement in the dielectric strength of SF ₆ gas insulation. Experiments show that the addition of a small amount of trichlorotrifluoroethane (R113) vapor cannot only increase the breakdown voltages within the corona stabilization region, but also improve corona onset voltages of SF ₆ in highly nonuniform field gaps. This additive is found superior to those used by other investigators in improving corona stabilization. Experimental results also show that the explanation of the effect of additives on corona stabilization suggested hitherto, should be reconsidered.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4081483
Influence of Arc-Decomposed SF ₆ Gas on Cast EPOXY Insulators for Gas Insulated Switchgears	Tominaga, Shotaro; Kuwahara, Hiroshi; Hirooka, Koichi	Mitsubishi Electric Corporation	Power Apparatus and Systems, IEEE Transactions on	1979	Reactions between arc decomposed gases and cast epoxy insulators used in gas insulated switchgears are very important and interesting phenomena to be investigated for engineers and designers.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4113728



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Estimation of Burn-Through Probability in SF6 Insulated Substations	Chu, F. Y.; Ford, G. L.; Law, C. K.	Research Division Ontario Hydro	Power Apparatus and Systems, IEEE Transactions on	1982	Enclosure burn-through in SF6 insulated substations is a rarely occurring event; however, in view of the possibly damaging effects to equipment and personnel, its probability of occurrence warrants a closer examination. This paper presents a model for estimating the likelihood of enclosure burn-through or pressure relief disc bursting during an in-service fault in SF6 substations. Results of a simulation show a 25% burn-through probability per fault in substations with the most probable fault currents in the 50 kA range. The probability of personnel being exposed to the hazardous arcing by-products is discussed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4111473
Experience with SF6 Gas-Insulated Substations and Proposals for Improved Reliability	Lindsay, C.; Hick, M.	Ontario Hydro	Power Apparatus and Systems, IEEE Transactions on	1984	Ontario Hydro has had four or more years of service experience with four gas-insulated substations (GIS) rated at 500 kV and 230 kV and 80 kA. Initially, the stations were fraught with problems, due mainly to the equipment being prototype. Most of the problems have now been corrected and the reliability and maintainability of the stations are satisfactory, comparable to the rest of the system. A number of proposals are made to improve the reliability of future GIS.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4112864
Investigation on the Reliability of Large Interrupting Capacity SF6 Gas Circuit Breaker With Few Breaks	Kobayashi, Y.; Kosugi, K.; Takagi, H.; Takayama, H.; Ueda, T.; Kobayashi, A.	Toshiba Corporation	Power Apparatus and Systems, IEEE Transactions on	1985	To improve the reliability of a newly developed puffer-type SF6 gas circuit breaker hydraulically operated, with single-break at 300kV and two-break at 550kV, various investigations are conducted. For the hydraulic operating mechanism, the driving characteristics are studied both by computer estimations and by actual tests. A pilot valve with an opening time of 4ms is developed. Repetitive breaking tests of the line charging current and the terminal fault condition are performed. The circuit breaker displays no problems in breaking this condition. As to the 550kV 2-break circuit breaker, a full-pole breaking test is conducted to verify insulation performance between the end of the breaking chamber and the tank.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4112911



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Design of SF6 Gas Characters Monitoring System Based on GPRS	Zhang Aiju	Sch. of Inf. & Safety Eng., Zhongnan Univ. of Econ. & Law, Wuhan, China	Management of e-Commerce and e-Government (ICMeCG), 2012 International Conference on	2012	In this design, developers use technology of GPRS and embedded system to monitor density and humidity of sulfur hexafluoride in electric equipment directly based on the GPRS and the Internet. In this paper developers introduce the application and relevant technology of GPRS used in the electric power system. And the design resolved the problem of wireless monitoring of unmanned transformer.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6374891
Designing Reliability into an SF6 Recloser System for Distribution Automation	Stewart, J. S.; Westrom, A. C.	Brush Switchgear Ltd. Loughborough - U.K.	Power Delivery, IEEE Transactions on	1987	An automatic circuit recloser has been made available having the features desired for present and future 5kV, 15kV, 25kV and 35kV distribution systems The three phase recloser designated type GIR is designed with a rotating arc interrupter where SF6 gas is used for the interrupter and the insulation. A microprocessor based control unit provides adaptability with presently installed protective devices and is fully adjustable in the field to changing system conditions. The control unit can be interrogated locally or remotely for fault history. Power requirements are so low that the life of the lithium battery is 10 years without the need for a charge circuit. The basic design concepts employed have provided for an increased maintenance interval.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4308179
Ground Fault By Restriking Surge of SF6 Gas-Insulated Disconnecting Switch and Its Synthetic Tests	Nishiwaki, S.; Kanno, Y.; Sato, S.; Haginomori, E.; Yamashita, S.; Yanabu, S.	Toshiba Corporation	Power Apparatus and Systems, IEEE Transactions on	1983	<div style="font-variant: small-caps; font-size: .9em;">First Page of the Article</div>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4111957



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Research on the model of HV SF6 circuit breaker fault diagnosis based on fuzzy theory	Huang Lingjie; Wang Wei; Wu Zhensheng; Xu Lijie	Sch. of Electr. Eng., Beijing Jiaotong Univ., Beijing	Condition Monitoring and Diagnosis, 2008. CMD 2008. International Conference on	2008	<p>High voltage circuit breaker (HVCB) is one of the most important equipments for controlling and operating in power system. In order to increase the reliability and safety of power system, it is necessary to carry on online monitoring and failure diagnosis on HVCB. However there are many difficulties in HVCB failure diagnosis. Based on fuzzy diagnosis theory, a fault diagnosis model of high voltage SF₆ circuit breaker is presented in this paper. By analyzing the frequent and common failures, this paper confirms the items of online monitoring of HVCB. Moreover, it digs the relationship between the characteristic parameters and the failures. Subsequently, this paper defines the failures array, failure symptoms array and fuzzy relational matrix. Then, it gives the optimistic fuzzy operator and diagnosis rules. For improving the veracity of fuzzy diagnosis system, this paper also proposes adaptive correction methods of the fuzzy relational matrix. The fuzzy diagnosis overcomes the difficulties that expert systems obtain knowledge, and neural networks need large numbers of data to be trained. The practical examples show that the algorithm is convenient to use, and the results are accurate. So the algorithm can be widely applied to fault diagnosis of HVCB.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4580318



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Viable Options for Reducing Impedance in a 2.5 MV Multichanneling, Multigap SF6 Gas Switch	LeChien, R.K.; Gahl, J.M.	Sandia Nat. Labs., Albuquerque, NM	Power Modulator Symposium, 2006. Conference Record of the 2006 Twenty-Seventh International	2006	An investigation was conducted into factors that effect impedance for a 2.5 MV gas switch. The switch studied was Rimfire, the workhorse gas switch topology for many of Sandia's large accelerators. The geometry of the switch investigated consists of multiple self-break gaps in series with a laser triggered main gap. The switch is situated within a coaxial-like ground return structure. In this geometry there are three avenues that are theoretically possible for reducing switch impedance. They are: 1) increasing the number of parallel current sharing channels (multichanneling), 2) decreasing the ratio of radii of the outer to inner conductors, and/or 3) decreasing the length. It was experimentally determined what effects the first two factors have on switch impedance and the results are presented in this work. It was discovered that multichanneling and radii ratio have substantially lesser effects on impedance, when compared to the theoretical effects of a reduction in switch length. This leaves reduction in length as the only remaining significant viable option for reduction of impedance in megavolt multigap switches, which has substantial consequences for the future design of multigap switches	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4216168



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Analysis and suggestions of several malfunctions based on SF ₆ GIS facilities in capital construction or operation	Wang Run-hua	Extra High Voltage Transm. Co., Shanghai Municipal Electr. Power Co., Shanghai, China	Electricity Distribution (CICED), 2010 China International Conference on	2010	SF ₆ electrical facilities malfunction contains these types: Forced fault (discharging channels mostly related to solid insulation, electric insulation cannot recover after high-energy discharge) and flexible fault (discharging channels mostly related to SF ₆ gas insulation or the combination of gas insulation and solid insulation, electric insulation recovers after high-energy discharge). Character of SF ₆ electrical facilities malfunctions can be determined by means of SO ₂ and H ₂ S fast-local-detection. This essay expatiates on SF ₆ electrical facilities discharging malfunctions, including estimation evidence, type, part, and discharging current. Through conventional and unconventional chemical, electrical test instruments, through investigation on solid powder, gas composition and chemical materials in GIS SF ₆ CT gas chamber before and after the flashover fault, it comes to the conclusion that inner CT with frequent flashover fault contains nitrile butadiene rubber board. The corrosive sulfur reacting with the contact part plating silver produces silver sulfide. It forms the discharging channel finally, which causes the arc-over in the CT chamber.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5736189
Identification of DC corona generating SF ₆ decomposition gases adsorbed on CNT gas sensor using FTIR spectroscopy	Martin, Y.; Zhenyu Li; Tsutsumi, T.; Suehiro, J.; Imasaka, K.; Ohtsuka, S.	Dept. of Electr. & Electron. Eng., Kyushu Univ., Fukuoka, Japan	TENCON 2010 - 2010 IEEE Region 10 Conference	2010	It is important to detect decomposition of insulating gas SF ₆ caused by partial discharges for gas-insulated switchgear (GIS). In the previous result, the author developed a novel partial discharges sensing using carbon nanotube (CNT) gas sensor. In recently, an application of high voltage DC for long distance electric power transmission has been often used in various countries as the interconnection system and overload demand. In this study we applied the CNT gas sensor to detect partial discharges generated by high voltage DC. There was polarity profile for DC compared AC discharges. It was found, response of the sensor in the case of negative discharges was much higher than positive discharges under the same experimental condition. And the decomposed gases for each case were identified by FT-IR spectroscopy. The result indicated absorption peaks correspond to SF ₄ and SO ₂ of positive discharges was much higher than that of negative discharges.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5686640



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Evaluation of UHF method for partial discharge measurement by simultaneous observation of UHF signal and current pulse waveforms	Yoshida, M.; Kojima, H.; Hayakawa, N.; Endo, F.; Okubo, H.	Nagoya Univ., Nagoya, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2011	The partial discharge - current pulse waveform analyzing (PD-CPWA) system can measure partial discharge (PD) current pulses continuously in high speed, and is being used for the study of PD mechanisms in SF ₆ gas in a laboratory. On the other hand, the ultra high frequency (UHF) method is becoming popular for the on-site monitoring of gas-insulated switchgears (GIS). The former can detect PD with high accuracy and make it possible to analyze and understand discharge physics in detail. The latter is suitable to detect PD in actual power equipment, even in noisy site condition. Clarification of coincidence of PD characteristics measured with both methods is very important for further application of the UHF method. In this paper, PD current pulses generated from artificial defects in SF ₆ gas were synchronously measured with both methods. Measured data were analyzed and compared in many PD characteristics. As a result, many characteristics coincided well between them. However, the scatter of PD and the limited equipment performance of the UHF method may cause some detection failures. An appropriate and advanced use of the UHF method was pointed out.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5739446



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
A study of PD location issues in GIS using FDTD simulation	Xiao Hu; Judd, M.D.; Siew, W.H.	Univ. of Strathclyde, Glasgow, UK	Universities Power Engineering Conference (UPEC), 2010 45th International	2010	<p>An effective way of measuring partial discharge (PD) for GIS is the UHF method, by which both PD detection and location can be realized. PD location is based on time-of-flight calculation in which travelling paths of electromagnetic signals between two sensors are assumed to be axially along the centre of GIS. The location is therefore normally obtained by solving a one dimensional problem, as if the GIS was in a continuous straight line. However, usually GIS must be made very compact, which can require many right angle bends or tee sections. The effect of corners and tee sections is to give greater significance to the three dimensional character of the PD location space. In particular, when a sensor is located close to a tee section, depending on where it is mounted on the tank circumference, the location result may vary because it does not consider the three dimensional relationship between this sensor and another sensor in a different arm of the tee section. This paper describes an investigation into the PD location accuracy in GIS tee sections using the Finite Difference Time Domain (FDTD) method to simulate the propagation of electromagnetic signals radiated by a PD. A tee section model of GIS was defined and a PD current pulse measured in SF₆ was used to quantify the waveshape of the excitation source. Simulations were carried out and electric fields were monitored at various points where UHF sensors might be installed around the tee section. PD location was evaluated by time-of-flight calculation and the location errors were analyzed. By these means, potential inaccuracies of PD location in GIS were investigated and quantified. Conclusions were drawn regarding the positioning of UHF sensors to reduce the location error.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5650033



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Partial discharges and associated mechanisms for micro gap delamination at epoxy spacer in GIS	Mansour, D.-E.A.; Kojima, H.; Hayakawa, N.; Endo, F.; Okubo, H.	Dept. of Electr. Eng. & Comput. Sci., Nagoya Univ., Nagoya, Japan	Dielectrics and Electrical Insulation, IEEE Transactions on	2010	<p>For accurate detection and diagnosis of Partial Discharges (PDs) in Gas Insulated Switchgears (GISs), there is a need for better understanding of the physical mechanisms for the PD activity. Accordingly, we have been investigating the PD characteristics and associated mechanisms for electrode/epoxy delamination of GIS spacers as one of the severest defects in GIS. The gas pressure inside delamination usually changes from sub-atmospheric pressure, just after delamination initiates, to filled SF₆ gas pressure in the GIS tank, after SF₆ gas infiltrates into the delamination area. Therefore, in this paper, the PD activity at different gas pressures, from 0.02 to 0.4 MPa, is acquired. Delamination gap length at the level of 50 μm is considered, simulating possible size of actual delamination in a GIS spacer. The relative PD generation rate is analyzed regarding the phase characteristics at different pressures and then discussed from the viewpoint of PD mechanism in order to assess the possibility of delamination diagnosis in GIS spacers. Experimental results show that, PD parameters and phase characteristics change significantly with infiltrating SF₆ gas from the GIS tank into the delamination. The obtained results give a characterized feature for the delamination defect and can be useful for delamination diagnosis.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5492259



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
The perspective detection of the X-ray digital radiography for the electrical equipment	Hong Yu; Jie Wei; Xianping Zhao; Yi Ma; Lei Chen	Electr. Power Res. Inst., Yunnan Electr. Power Test & Res. Group Co., Ltd., Kunming, China	High Voltage Engineering and Application (ICHVE), 2012 International Conference on	2012	<p>The manufacture and installation factor is quite large occupied in the induced factor of electrical equipment insulation defects. However, the nowadays technology methods of the power system, such as ultrasonic, partial discharge, which the abnormalities can be found, but the detection data are not visual, uncertainty is existed in the results decision and blindness has in the maintenance strategy. Aiming at the above shortcoming, in this paper, it is proposed the utilization X-ray digital radiography (DR) technology to detect the power facilities. In order to know the influence of electrical facilities insulation medium, the research is done by the highest energy of the X-ray, and is determined the application range of X-ray DR system. Determining the X-ray DR system application scope in the power equipment, the GIS typical defects are simulated and visualized detection. After the X-ray DR system is utilized to detect the facilities in the power production field. The experimental results demonstrate that the X-ray DR detecting system does not any influence for the solid and SF₆ gas of the insulation medium, and the insulation oil has influence by the X-ray long time irradiation. The power equipment is visual detected by the X-ray digital radiography system without power cut and disintegration. Thus, the X-ray digital radiography system is used to detect the power facilities, which is feasible, safe and effect.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6357096



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Numerical analysis of electric field for 1100kV disconnecter in GIS based on two kinds of structures	Lu lu; Lin Xin; Xu Jianyuan; Li Shuang	Shenyang Univ. of Technol., Shenyang, China	High Voltage Engineering and Application, 2008. ICHVE 2008. International Conference on	2008	The 1100 kV GIS disconnecter is the electrical equipment which was used in the 1000 kV UHV AC testing demonstration pilot project. Based on two different kinds of structures, three dimensional electric field of 1100 kV SF6 disconnecter airchamer are analyzed by using the finite element software. For the complex Analysis the extra-high voltage disconnecter airchamer, its volume is big and the structure is complex, applies in the different line situation. By analyzing the electrical field intensity distribution of disconnecter airchamber, the distribution nephogram of the whole area and the maximal electric field intensity area are attained and the comparisons between two distributions are done. Then theoretical basis for construction design of disconnecter is supplied according to the analyzed results of electrical field.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4773989
Design features of GIS	Arora, A.; Koch, H.		Power Engineering Society General Meeting, 2005. IEEE	2005	This paper presents the design of GIS based on the long experiences of AIS equipment with all its improvements. The use of pressurized SF6 as insulating and arc extinguishing medium within gastight housing brought up a new design for the main elements of a substation. GIS technology typically is of modular design and filled with a minimum of SF6. It is characterized by its low life-cycle cost (LCC) and can be used for indoor and outdoor application. Today, changes in the general substation layout, making use of the specific design features of a GIS, are considered.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1489160



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Dynamic behaviors of the streamer development and propagation in SF ₆	Dianchun Zheng; Shihua Zhu; Zhonglin Zhang; Shuming Lv	Key Lab. of Eng. Dielectr. & Its Applic., Harbin Univ. of Sci. & Technol., Harbin, China	Electric Power Equipment - Switching Technology (ICEPE-ST), 2011 1st International Conference on	2011	SF ₆ gas is an important insulated medium and is widely used in electric power industry for gas-insulated equipment; this paper aims to deeply understand the streamer discharge mechanism in SF ₆ , and to better use of SF ₆ gas in the electrical equipment. The two dimensional and self-consistent fluid model of the gas discharge is established based on the electron and ions continuity transfer equations coupled to Poisson's equation, furthermore including the model of photoionization. To overcome the problem about enormous calculation required of photoionization, some simplified methods are implemented in this paper. In simulation, the particle flux-continuity equations is solved by the flux corrected transport technique (FCT), and the iterative symmetric successive over-relaxation (SOR) method is used to solve the coupling Poisson's equation. Results of two-dimensional simulation of cylindrically symmetric streamer in SF ₆ between parallel-plane electrodes are obtained. We present and discuss conclusions about streamer transport based on the results of these studies. The temporal and spatial transformation of charged particle densities, electric field strength, discharge current and discharge propagation velocity during the progression of discharges are investigated and the results indicated that, the processes of discharge have three phases: avalanche phase, streamer formation phase and streamer propagation phase. In addition, by comparing the results of simulation with and without photoionization process can be seen that the photoionization offers a large number second electron, and is absolutely necessary during the streamer propagation phase, which accelerates the velocity of the streamer propagation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6123041



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
The strengths and weaknesses of Vacuum Circuit Breaker technology	Falkingham, L.T.	Vacuum Interrupters Ltd., UK	Electric Power Equipment - Switching Technology (ICEPE-ST), 2011 1st International Conference on	2011	Vacuum switchgear is today the dominant technology worldwide for Medium Voltages up to 52kV, and is seen as the main candidate to replace SF6 circuit breakers at higher voltages. Vacuum switching technology was introduced into service in the late 1960's and since that time millions of vacuum circuit breakers have been manufactured. Today it is estimated that over a million vacuum circuit breakers will be manufactured worldwide annually. Vacuum circuit breaker technology now has been in large scale use for more than 40 years and has an enviable reputation for reliability in service. However amongst the very large numbers in service there are still occasional failures, and historically, particularly in the early days, there have been some problems due mainly to misapplication of the technology both by manufacturers and users. This paper examines the basics of Vacuum Circuit Breaker and particularly Vacuum Interrupter technology in order to identify their strengths and weaknesses. All technologies have their strengths and weaknesses and an understanding of what these are, and their effect on performance, permits the technology to be applied most effectively. The paper concludes that what are considered strengths and weaknesses of vacuum switchgear specific to the vacuum technology, particularly related to the vacuum interrupter, are in many cases the identical phenomena. The concept of strength or weakness being mainly related to the application or specific situation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6122975
The Effect of GIS Apparatus Parameter on Very Fast transient Over-voltage	Meng Tao; Lin Xin; Xu Jianyuan	Sch. of Electr. Eng., Shenyang Univ. of Technol., Shenyang, China	High Voltage Engineering and Application, 2008. ICHVE 2008. International Conference on	2008	Based on a hydro-energy storage station, the very fast transient over-voltage in GIS is calculated and simulated using the FORTRAN language and Matlab program. The node with the maximum of the VFTO is found. The suppression effect of cable and SF ₆ busbar is discussed, and the influence the shunted capacitor is analyzed in the paper. It is indicated that the VFTO peak-values may be restricted by increasing the length of the cable and the SF ₆ busbar properly, and frequency may be lowered. In addition, and the VFTO peak magnitude may be varied with the capacity of the shunted capacitor.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4773931



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Research on intelligent GIS on-line status monitoring	Shen Chunhong; Zhang Kuwa; Gu Qun	Xi'an XD Switchgear Electr. Co., Ltd., Xi'an, China	Electric Power Equipment - Switching Technology (ICEPE-ST), 2011 1st International Conference on	2011	With the development of the work that "constructing strong intelligent power grid", intelligent substation system become into the main develop direction. This paper mainly takes research on the on-line monitoring technology about GIS breaker mechanical properties, partial discharge and SF6 gas pressure. By analyzing various on-line monitoring technologies and contrasting the advantages and disadvantages of them, the paper summarize the monitoring technology suitable for GIS equipment and put forward the viewpoint that the integrated design of the traditional high voltage switch equipment and intelligent elements should give first place to the primary equipment. This paper proposes the monitoring technology suitable for GIS based on keeping the primary equipment safe and reliable. The research would provide reference and basis for the subsequent development of intelligent GIS on-line monitoring system.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6122996
Developing norm for SF ₆ quality of tropical GIS	Bastian, A.; Rahmani, D.S.; Muchtar, A.	P3B Jawa Bali, PT PLN (Persero), Depok, Indonesia	Condition Monitoring and Diagnosis (CMD), 2012 International Conference on	2012	The climate of Indonesia is almost entirely tropical. The uniformly warm waters that make up 81 % of Indonesia's area ensure that temperatures on land remain fairly constant, with the coastal plains averaging 28°C, the inland and mountain areas averaging 26 °C, and the higher mountain regions, 23 °C. It is huge difference between tropical weather compared to subtropical weather conditions. To identify the level of SF6 quality we use SF6 gas norm of the restriction of range value CIGRE. Data obtained from the test results over five years by using 30 samples. The method used used to obtain norm is a statistical method.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6416176



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Low jitter, high voltage, repetitive laser triggered gas switches	Hegeler, F.; Myers, M.C.; Wolford, M.F.; Sethian, J.D.; Fielding, A.M.	Commonwealth Technol., Inc., Alexandria, VA, USA	Dielectrics and Electrical Insulation, IEEE Transactions on	2013	The Electra pulsed power system at the Naval Research Laboratory is capable of supplying 16 kJ to a low impedance load within 140 ns, and it allows continuous operation of up to 5 pulses per second for several hours. Four laser triggered SF6 gas switches transfer the stored pulse forming line energy to the load. Each switch has a hold-off voltage of more than 1 MV and transfers a charge of 10 mC per shot. This paper describes the redesign of the gas switch with hemispherical electrodes to a flat electrode configuration, which led to an improvement in switch reliability. A one sigma switch jitter of ± 1.2 ns has been achieved for tens of thousands of continuous shots, with an electrode erosion rate as low as 1 mg/C. Detailed statistical analyses are provided when the switches are operated at a SF6 pressure of 0.36 - 0.69 MPa, with a laser trigger energy of 1 - 18 mJ at 266 nm, and a switch hold-off voltage ranging from 0.7 - 1.2 MV.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6571432
Characterization of Paschen curve anomalies at high P*D values	Carey, W.J.; Wiebe, A. J.; Nord, R. D.; Altgilbers, L.L.	ARC Technol., Whitewater, KS, USA	Pulsed Power Conference (PPC), 2011 IEEE	2011	Paschen's law is often used to estimate the breakdown voltage of high pressure gas switches commonly used in high voltage pulsed power systems based on the product of pressure and distance (pd) in a given gas. Paschen's law predicts breakdown voltages for high pd values that scale approximately linearly with pd. However, it is clear from published literature and ARC Technology's experimental data that the breakdown voltage deviates significantly from the theoretical Paschen curve at relatively high pd product values. It is also clear that these results are not consistent for different gap spacings and pressures with the same pd product. Therefore, initial tests have been performed to characterize this region of the paschen curve for N2, H2, and SF6 for pressures between 96.5 and 6900kPa and gap spacings of 0.508, 1.27 and 2.54 mm.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6191503



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Calculation of the interruption capability of SF ₆ -CF ₄ and SF ₆ -C ₂ F ₆ mixtures. I. Plasma properties	Chervy, B.; Riad, H.; Gleizes, A.	Univ. Paul Sabatier, Toulouse, France	Plasma Science, IEEE Transactions on	1996	For a gas used in circuit breakers, the extinction capability corresponds roughly to the rate of evolution of the electrical resistance during the arc decay. This property is very prominent for SF ₆ which explains its wide use in high-voltage circuit breakers. But in severe winter conditions, this gas may partially liquefy, and some mixtures of SF ₆ with other gases are considered. The present work deals with a calculation of the extinction capability of SF ₆ -CF ₄ and SF ₆ -C ₂ F ₆ mixtures. This first paper consists of the study of the material functions of the plasma assumed to be in local thermal equilibrium (LTE). The equilibrium composition and the thermodynamic properties have been calculated from the partition functions. The transport coefficients have been computed by the method of Chapman-Enskog and the net emission coefficient obtained assuming isothermal and homogeneous plasma. CF ₄ and C ₂ F ₆ present dissociation phenomena analogous to those of SF ₆ which leads to similar variations of mass density, specific heat, and thermal conductivity. The electrical conductivities are practically identical for all the mixtures. The net emission coefficient is enhanced by the presence of carbon in spite of a strong absorption of the resonance lines	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=491760
Changes in switchgear design: a manufacturers experience	Stewart, J. S.	GEC Alsthom Transmission & Distribution Projects Ltd., Stafford, UK	SF ₆ and Vacuum Switchgear at Distribution Levels (Digest No. 1996/185), IEE Colloquium on an Update in	1996	Switchgear designers are constantly striving to produce smaller, better, lower cost equipment to win orders and improve their position within the industry. They do this by making use of the latest technology in interruption, materials, design aids and manufacture. Whilst it is possible for manufacturers to produce novel designs of switchgear in various technologies, trends in switchgear are determined by the user. It has been shown that users are increasingly moving towards vacuum and SF ₆ from oil, in order to reduce the cost of ownership which includes the costs associated with maintenance. The author discusses the design of both vacuum and SF ₆ switchgear, standards, protection and control, and future trends	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=598307

Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Practicalities of using SF ₆ and vacuum switchgear	Balnaves, D.	Midlands Electr. plc, UK	SF ₆ and Vacuum Switchgear at Distribution Levels (Digest No. 1996/185), IEE Colloquium on an Update in	1996	The choice of nonoil switchgear for distribution networks has been available to the electricity industry for nearly 20 years. This paper highlights some of the problems, potential risks and safety issues to both the network and operators when using nonoil switchgear. Substation design, switchgear failure and maintenance are also discussed	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=598311
SF ₆ Gas Analysis Technique and its Application for Evaluation of Internal Conditions in SF ₆ Gas Equipment	Tominaga, Shotaro; Kuwahara, Hiroshi; Hirooka, Koichi; Yoshioka, T.	Mitsubishi Electric Corporation	Power Apparatus and Systems, IEEE Transactions on	1981	A number of standards have been established on the gas analysis of SF ₆ gas equipment. Throughout the past 15 year record of manufacturing SF ₆ gas equipment, gas analysis has been made by the authors on a number of apparatus in operation, as well as on simulation tests of various conditions. The results showed that gas analysis is effective in the diagnosis of SF ₆ gas equipment and that a gas checking type detector is quite suitable for field tests.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=411117
Electric Potential and Field of Conical Insulators for SF ₆ Metalclad Switchgear	Menju, S.; Tsuchikawa, Y.; Kobayashi, N.	Tokyo Shibaura Electric Company, Ltd.	Power Apparatus and Systems, IEEE Transactions on	1972	Potential gradient at the surface of the electrode is the most important factor in the breakdown of SF ₆ gas gaps as has been reported in the previous papers. 1, 2	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4074729
Effects of arcs in enclosures filled with SF ₆ and steps taken to restrict them in SF ₆ switchgear	Strasser, H.; Schmidt, K. D.; Hogg, P.	Brown, Boveri Baden, Switzerland	Power Apparatus and Systems, IEEE Transactions on	1975	For internal arc faults in metalclad SF ₆ switchgear the main parameters fault current, arc voltage, fault duration, enclosed volume and material of the enclosure are discussed in relation to test results. The effects in connection with pressure rise and melting through are stated, from which the requirements to be complied with by SF ₆ installations are derived. Measures to restrict the effects of arc faults are compared and a solution deduced which satisfies the requirements imposed.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1601541



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Cold Characteristic Development Test of a New SF6 High Voltage Circuit Breaker	Ramming, L.; Aristizabal, M.	ETH, Zurich	Transmission & Distribution Conference and Exposition: Latin America, 2006. TDC '06. IEEE/PES	2006	Computer controlled triggering of an impulse generator was implemented in order to perform precisely timed lightning impulse voltage discharges on a new SF ₆ high voltage circuit breaker while performing a trip operation. Successive discharges at different time intervals would provide an envelope of dielectric withstand and travel characteristic of the specific high voltage circuit breaker. This test not only evaluates the interrupter gap design but also evaluates the gas flow effect in the dynamic dielectric recovery of the interrupter chamber. Gas flow characteristics in the interruption chamber of an SF ₆ breaker strongly modifies the dielectric withstand recovery rate of any design. Identifying any weakness before power test are performed not only reduces cost and time, but also simplifies design modifications required and provides an insight into the expected performance of the interrupting chamber during actual synthetic power testing. This paper presents the implementation of this testing procedure as well as the results obtained in a new design of a 245 kV, 63 kA SF ₆ interrupter	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4104701
Safety and environmental evaluation of insulating media in medium-voltage distribution equipment	Yanniello, R.; Paoletti, G.	Eaton Electr. Inc., Avery Creek, NC	Pulp and Paper Industry Technical Conference, 2008. PPIC 2008. Conference Record of 2008 54th Annual	2008	The hazards associated with performing maintenance on energized electrical equipment have been the subject of massive amounts of literature as well as the driver for numerous product innovations aimed at mitigating the effects of this hazard. The intent of this paper is to highlight potential personal and environmental dangers associated with this same equipment when it is de-energized. This paper is specifically targeted at switchgear and circuit breakers rated above 1000 V, and is more specifically targeted at personnel who perform maintenance, decommissioning, retrofitting, or clean up after catastrophic failures of this class of equipment.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4585824



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Application of 800-kV SF6 dead tank circuit breaker with transmission line surge arrester to control switching transient overvoltages	Musa, Y.I.; Keri, A. J F; Halladay, J.A.; Jagtiani, A.S.; Mandeville, J.D.; Johnnerfelt, B.; Stenström, L.; Khan, A.H.; Freeman, W.B.	American Electr. Power, Gahanna, OH, USA	Power Delivery, IEEE Transactions on	2002	An 800-kV metal oxide transmission line surge arrester (TLA) has been developed, installed and tested on the AEP 765-kV Marysville-Kammer transmission line. The purpose of this TLA is to pave the way for the development, construction and application of an 800-kV SF ₆ dead tank circuit breaker without closing resistors and free standing current transformers at American Electric Power's (AEP) 800-kV Orange station. Eight hundred kilovolts is the maximum design operating voltage, and 765 kV is the nominal operating voltage. Successful field test results of the TLAs ability to limit switching overvoltages emanating from circuit breaker operation to below the transmission line switching withstand are given. In addition, successful test results of the 800-kV dead tank circuit breaker design dielectric test are given in this paper.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1046869
Recent evolution of high-voltage SF6 circuit-breakers	Dufournet, D.	GEC Alsthom Transmission & Distribution Projects Ltd., Stafford, UK	Physics of Power Interruption, IEE Colloquium on	1995	For a long time, SF ₆ puffer circuit-breakers have been considered the most efficient and reliable type of interrupting switchgear. This technique was introduced by GEC ALSTHOM T&D (then DELLE ALSTHOM) at the end of the 1950s for medium voltage applications, and then extended in the 1960s to high-voltage circuit breakers. Since then, and until the end of the 1980s, it has been the dominant technique in the high voltage range. In the 1980s, GEC ALSTHOM T&D began to study a new generation of SF ₆ circuit breakers which can be operated by low-energy mechanisms and which were characterized by the use of arc energy for interruption. Here, the author examines the development of tools used in the design of circuit breakers, and describe the recent evolution of high-voltage circuit breakers	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=497160
Dielectric Breakdown of High Pressure SF6 in Sphere and Coaxial Cylinder Gaps	Menju, S.; Aoyagi, H.; Takahashi, K.; Qhno, H.	Tokyo Shibaura Electric Company, Ltd.	Power Apparatus and Systems, IEEE Transactions on	1974	This paper describes the breakdown characteristics of SF6 at pressures up to 15 kg/cm2 absolute at 20Å, Å°C against power frequency, switching impulse and lightning impulse voltages in sphere and coaxial cylinder gaps.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4075538



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Practical Problems on SF6 Gas Circuit Breakers	Ushio, T.; Shimura, I.; Tominaga, Shotaro	Mitsubishi Electric Corporation Itami Works	Power Apparatus and Systems, IEEE Transactions on	1971	The SF6 gas circuit breaker is getting a major position in the field of circuit breakers because of its excellent performance. On the way to putting them to practical use the authors made investigations to solve the several problems encountered, such as the control of moisture content in the gas, liquefaction, control of gas leakage, selection of O-ring materials, etc. This paper describes the results of these investigations and presents the solutions and counter-measures applied in practice.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4074579
A review of MV interrupting technology through the prism of a contemporary SF6 circuit breaker	Rose, A.	EE Tech. Resource Associates, West Orange, NJ, USA	Cement Industry Technical Conference, 1998. 40th Conference Record. 1998 IEEE/PCA	1998	In recent years, much has been documented on vacuum interrupter improvements. This paper focuses on an alternative technology in the form of arc quenching in SF ₆ gas by means of a rotating arc and thermal expansion. These parallel developments in SF ₆ circuit breakers make possible choices between vacuum and SF ₆ breakers. User identified criteria in evaluating the emergent and competing technologies are offered in an effort to provide an understanding of the differences in medium voltage switchgear technologies	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=679238
SF6 GIS Of Three-Phase Enclosure Concept For The Voltage Range Of 69 To 145 kV	Schmitz, W.; Watson, P. W.; Leibold, A.	Brown Boveri AG	Transmission and Distribution Conference and Exposition, 1979. 7 IEEE/PES	1979	<div style="font-variant: small-caps; font-size: .9em;">First Page of the Article</div>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=712722



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Linking a physical arc model with a black box arc model and verification	Ahmethodzic, A.; Kapetanovic, M.; Sokolija, K.; Smeets, R. P P; Kertesz, V.	Fac. for Electr. Eng. Sarajevo, Kampus Univerziteta Sarajevo, Sarajevo, Bosnia-Herzegovina	Dielectrics and Electrical Insulation, IEEE Transactions on	2011	<p>The arc behavior in the current zero region is critical in the case of very steep rising TRV, such as after clearing a short-line fault. Therefore, intensive and abundant short-line fault tests (L90) of a 245 kV SF6 circuit breaker were performed at the KEMA High Power Laboratory. For the purpose of a comparative analysis three different sets of data were obtained during the tests: 1) High-resolution measurements of near current-zero arc current and voltage were carried out. The current zero measurement system (CZM) works as a standalone system in addition to the standard laboratory data acquisition system. The arc conductance shortly before current zero and the arc voltage extinction peak give a clear indication of the interrupting capability of the breaker under test. 2) From the measured traces of every individual test, arc parameters (3 time constants and 3 cooling-power constants) were extracted for the composite black box arc model, which has been developed by KEMA High Power Laboratory and is based on more than 1000 high-resolution measurements during tests of commercial high-voltage circuit breakers. Its aim is to simulate interruption phenomenon in SF6 gas, evaluate performance of HV SF6 circuit breakers in testing and enable the prediction of the performance under conditions other than those tested. 3) After each test, using specially developed computer software, based on a simplified physical enthalpy flow arc model, the values of the arcing contact distance, gas mass flow through the nozzle throat and pressure inside the compression cylinder were calculated. The values of these characteristic quantities at the current zero are relevant indicators for successful interruption. In the comparative analysis, mathematical relations and statistical correlations between the evaluated parameters of the composite black box arc model and the characteristic output quantities are established and discussed. The link has been verified by MatLAB simulation of every individual test. This approach enables acceptable prediction of interruption success in a similar circuit and with a similar interrupter without SLF tests and CZM.</p>	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5976092



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Electrical Breakdown of Long Gaps in Sulfur Hexafluoride	Nitta, T.; Shibuya, Y.	Mitsubishi Electric Corporation	Power Apparatus and Systems, IEEE Transactions on	1971	The electrical discharge characteristics of SF ₆ are discussed theoretically in relation to the field dependence of the ionization coefficient α and the electron attachment coefficient. The results are compared with the characteristics of air. A simple theoretical formulation of breakdown or corona inception voltages of gaps in SF ₆ is derived. The formulation has been examined by experiments on several electrode configurations. At low pressures of less than 4 atm, the agreement of the theoretical and the experimental results is fairly good. The breakdown voltage decreases from the theoretical estimation at higher pressure.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4074433
Diagnostic Technique for Mechanical Failures of Gas Circuit Breakers	Ikeda, S.; Aoyagi, A.; Amemiya, T.	Toshiba Corporation	Power Apparatus and Systems, IEEE Transactions on	1981	Experimental studies have been made to develop an effective technique for diagnosing mechanical failures of SF ₆ gas circuit breakers (GCB) from the outside. In order to verify the effectiveness of this methods, GCB was assembled, simulated defective parts being included, and was operated at a very low operating speed. The changes of the driving force, vibratory acceleration and stroke of the moving parts were measured during such operation.	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4110593



Título	Autores	Institución	Publicación	Año	Resumen	Link al pdf
Scaling SF ₆ helical arc interrupters for performance gain	Ennis, M.G.; Turner, D.R.; Spencer, J.W.; Jones, G.R.	Liverpool Univ., UK	SF ₆ and Vacuum Switchgear at Distribution Levels (Digest No. 1996/185), IEE Colloquium on an Update in	1996	Simplistically the debate about the relative merits of vacuum and SF ₆ for power electrical engineering applications is often based upon dielectric withstand capabilities of the two media. Thus the exclusive use of SF ₆ for EHV applications may superficially derive from its superior breakdown strength when moderately pressurised. There are, of course, other factors which govern technical choices for particular applications. For example the use of hologenic traces in Geiger Muller particle counters rather than vacuum alone was based upon their ionic scavenging action to produce better time resolution for particle detection. In the area of distribution circuit breakers the comparisons which need to be made between vacuum and SF ₆ centre around the SF ₆ rotary arc circuit breakers. This paper deals with one type of such circuit breaker which utilises the arc in a helical form. It is shown that ideal dielectric strength considerations alone are insufficient on which to base choices but that the helical arc device offers considerable scope for future design development. Hitherto insufficient knowledge and understanding of several fundamental aspects of helical arcing has prevented full advantage to be taken of this type of device. An attempt is made through this paper to describe some of these newer fundamental aspects and the manner in which they may impact on future design considerations for rotary arc circuit breakers	http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=598310