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CONFERENCE INTERNATIONALES DES GRANDS RESEAUX ELECTRIQUES A HAUTE TENSION

INTERNATIONAL CONFERENCE ON LARGE HIGH VOLTAGE ELECTRIC SYSTEMS

AN ANNOTED BIBLIOGRAPHYH ON
UHV AC SUBSTATION EQUIPMENT
1968-1985

Prepared by

Working Group 38-04

Task Force No. 3

UHV TRANSFORMERS AND SUBSTATION EQUIPMENT, INCLUDING GIS EQUIPMENT

Edited by

Stig A. Annestrand

Co-ordinator, Task Force No. 3

Report presented to Study Committee 38

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MEMBERS OF CIGRE TASK FORCE 38-04.03

UHV TRANSFORMERS AND SUBSTATION EQUIPMENT INCLUDING GIS EQUIPMENT

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Report presented at the request of

Chairman of Study Committee 38

Dr. H. Ellis

Chairman of Working Group 38-04

Dr. G. Manzoni

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INSULATION COORDINATION -IC-

[1968] IC-001
INSULATION COORDINATION OF THE 1100 kV WALTZ MILL STATION. J.P. McKinnon, A.R. Hileman, J.K. Dillard. American Power Conference Proceedings, vol. 30, 1968, pp. 1010-1016. The 1100 kV project, announced in July 1967, will provide facilities for testing samples of cable and other underground systems for 121 kV to 765 kV service. Sponsored by the Electric Research Council, this project's design, construction, and operation is under contract with the Edison Electric Institute by Westinghouse. To permit testing to 150 percent overvoltage on 765 kV samples, the maximum phase-to-phase test voltage will be 1100 kV. The design philosophy focused on a station to serve as a prototype of future 1100 kV commercial stations. Switching surge and impulse tests were made on external porcelain and air insulations to verify and extend existing data. Results, with data already existing, provided design information as well as more accurate assessments for future 1100 kV system requirements, the intent is to make future systems reliable and economical. This paper discusses the philosophy of the changes in design criteria and their effects on this test station and of future 1100 kV transmission systems. (Abstract from article)

[1968] IC-REF
1000 kV TESTING TRANSFORMER FOR N.V. KEMA (in Dutch). J.M.H. Claessen, P.B. Versteegen. Smit. Meded, vol. 23, no. 3, Sept. 1968, pp. 99-111. For abstract, see entry [1968] TF-001.

[1968] IC-REF
1100 kV STATION AND LINE INSULATION DESIGN. J.K. Dillard, A.R. Hileman, J.P. McKinnon. CIGRE, 1968, paper 25-06. For abstract, see entry [1968] STA-001.

[1969] IC-002
ANACOM STUDIES FOR AN 1100 kV TRANSMISSION SYSTEM. J.K. Dillard, J.M. Clayton, L.A. Kilar. American Power Conference Proceedings, vol. 31, 1969, pp. 834-841. Several studies were conducted on the Anacom to evaluate the effectiveness of various alternatives for limiting switching surges. Among these were multi-step resistor breakers, controlled closing breakers, use of shunt reactors, single-pole reclosing, and discharging the lines before reclosing. Major findings are reported in this paper. (IEE abstract, from Inspec)

[1969] IC-REF
VARYING RESISTOR SIZE REDUCES SYSTEM SWITCHING SURGES. J.H. Harlow, A.E. Kilgour. American Power Conference Proceedings vol. 31, 1969, pp. 995-1003. For abstract, see entry [1969] SW-004.

[1970] IC-003
DIELECTRIC STRESSES (in Italian). G. Carrara, A. Clerici. Elettrotecnica, vol. 57, no. 10, Oct. 1970, pp. 581-593. The dielectric stresses in EHV and UHV electric power systems are examined. Up-to-date methods for the evaluation of the stresses due to lightning discharges are reported. The overvoltages due to switching operations or to faults are examined, with particular attention to the various methods adopted in order to reduce them. Finally, a short survey of the main problems involved in the design of circuit breakers and surge diverters (lightning arresters) is given. (Engineering Index abstract, from Compendex)

[1970] IC-004
TRENDS IN REQUIREMENTS FOR LIGHTNING ARRESTERS. P.W. Bogner. Electric Utility Engineering Conference, Westinghouse Electricity Corp., March 15-27, 1970, Pittsburgh, Pennsylvania. During the past fifteen years there has been a systematic increase in transmission voltage level in the United States. The first 345 kV lines were put into service in the mid-1950s. This voltage was rapidly accepted; over 3000 circuit miles of transmission are operating at this voltage level. Since 1965 a number of 500 kV systems have been built and are operating succcessfully. A 765 kV system is under construction with an initial 68-mile section energized. In the future there will be UHV. Systems above 1000 kV and the design trends for lightning arrester equipment are discussed. (IEE abstract, from Inspec)

[1970] IC-005
SWITCHING OVERVOLTAGES IN EHV AND UHV NETWORKS. P. Baltensperger, E. Ruoss. CIGRE, 1970, paper 13-14. The authors describe the large variety of switching operations and network parameters influencing the size and shape of switching overvoltages. They summarize the present state of knowledge. Special attention is paid to possible means of limiting overvoltages. The main problems still to be investigated are listed. (Abstract from article)

[1970] IC-REF
CONTROLLING SWITCHING SURGES ON 1100-kV TRANSMISSION SYSTEMS. J.K. Dillard, J.M. Clayton, Jr., L.A. Kilar. IEEE Transactions, PAS, vol. 89, no. 8, Nov.-Dec. 1970, pp. 1752-1762. For abstract, see entry [1970] SW-006.

[1971] IC-006
HYDRO QUEBEC 735/765 kV SYSTEM WITH PARTICULAR REFERENCE TO EXTERNAL INSULATION COORDINATION AT EHV AND UHV. J.J. Archambault, D.T. McGillis. American Power Conference Proceedings, vol. 33, 1971, pp. 1050-1062. At Hydro Quebec, 735 kV transmission has proven a

very satisfactory choice of voltage level. Only moderate control of the switching surge is required to achieve a practical insulation level. The performance record has been excellent during the past five years. The economic integration of Manicouagen and Churchill into the network makes the possibility of even higher transmission voltages very attractive. For the development of future hydro sites, transmission at 1100 kV and 1500 kV is being considered. At 1100 kV more severe control of the overvoltages will be required, but this will prove a little arduous if the same risk of failure is to be maintained as with the 735 kV. At 1500 kV, it will probably be impossible to relate switching surges to the present conception of a transmission tower. (Abstract from article)

[1971] IC-007
TRENDS IN THE DESIGN OF HIGH-VOLTAGE LIGHTNING ARRESTERS. H.V. Gopalakrishna. Institution of Engineers Electrical Engineering Division Journal (India), vol. 11, no. 6, June 1971, pp. 31-35. The need for lightning arresters in EHV and UHV systems is briefly presented. Causes of switching overvoltages and their importance in the design of lightning arresters and insulation coordination are briefly indicated and the design of lightning arresters for combating switching surges is outlined. (IEE abstract, from Inspec)

[1971] IC-008
EPOXY-RESIN-IMPREGNATED PAPER INSULATION SYSTEM FOR ULTRA-HIGH-VOLTAGE APPLICATIONS. T. Isogai, N. Ikemoto, T. Inque. IEEE Transactions, EI, vol. 6, no. 3, June 1970, pp. 94-100. An epoxy-impregnated paper insulation is a resin-rich void-free structure, and therefore has extremely superior voltage withstand characteristics. It also has outstanding resistances to thermal cycle and mechanical vibration. Consequently, such an insulation system can be applied easily to condenser bushings. From the standpoint of the production facilities, techniques, and economical considerations, in items with an overall length of more than 3 M, "prefab" condenser bushings, consisting of several condenser cores, are desirable. When two-unit condenser cores are assembled leaving a simple conical-shaped gap between them. It is extremely effective to adopt a potential-expanding gap, designed so that the equipotential surface in the gap will be in the vertical position to the cone surfaces as far as possible. The prefab-type condenser bushing of the 500 kV class was experimentally manufactured using this arrangement; it displayed all the desired properties. This paper also describes other applications: current transformer bushings and pulse transformers in the magnetic firing system for HVDC converters using thyristors, and draw-out-type condenser bushing for disconnecting devices used in the compact-type substation. (IEE abstract, from Inspec)

[1971] IC-009
REDUCTION OF SWITCHING OVERVOLTAGES IN EHV AND UHV SYSTEMS. H.B. Thoren. IEEE Transactions, PAS, vol. 90, no. 3, May-June 1971, pp. 1321-1326. The reduction of switching overvoltages by means of synchronized circuit breakers with preinsertion resistors is studied. The influence of system and breaker parameters is ascertained. The study shows that the reduction obtainable in a shunt-compensated system is sufficient for future "Y" applications. A method for the rapid reinsertion of disconnected shunt reactors is also investigated. (Engineering Index abstract, from Compendex)

[1971] IC-REF
POWER CIRCUIT BREAKERS IN ULTRA-HIGH-VOLTAGE NETWORKS: TECHNICAL AND ECONOMICAL PROBLEMS AND SOLUTIONS (in German). P. Baltensperger. Elektrotechnische Zeitschrift, vol. 92, no. 12, 1971 pp. 690-694. For abstract, see entry [1971] SW-009.

[1972] IC-010
WET TESTS. N. Hylten-Cavallius. Canadian Communications & EHV Conference, Montreal, Nov. 9-10, 1972, IEEE publication no. 72 CHO 698-1-REG-7, pp. 149-150. The background is given for present-day wet test techniques. A new type of apparatus is described intended for large spraying distances. It uses oscillating nozzles supplied by pulsating water. Artificial wet tests as the means of simulating the effect of rain on outdoor insulation has been used in the high-voltage testing techniques at least since the 1930s, but two different practices developed in North America and in Europe. Efforts are being made to replace present wet test standard by more realistic ones. The apparatus described might also solve the difficulties of spraying distances needed for wet tests on system equipment at voltages higher than today's 750 kV. (Abstract from article)

[1972] IC-011
PHASE-TO-PHASE SWITCHING IMPULSE STRENGTH OF AIR CLEARANCES IN UHV SUBSTATIONS. G.N. Alexandrov, G.N. Gerasimov, J.A. Redkov, V.P. Lyskov. Elektrichestro, no. 10, translated in Electrical Technology USSR, (U.K.), vol. 4, 1972, pp. 1-16. The article reports results of tests on models of insulating air gaps for 750 and 1200 kV substations. The necessary distance between the phases is found to be at least 5, 7 and 9 m for these voltage classes according to the distance between screens. (Abstract from article)

[1972] IC-012
ELECTRIC UTILITIES EXPLORE UHV. G.M. McAllister. Canadian Communications & EHV Conference, Montreal, Nov. 9-10, 1972, IEEE publication no. 72 CHO 698-1-REG-7, pp. 99-100. This paper provides a short discussion of

the research in UHV power transmission which has been initiated by the electric utilities throughout the world in conjunction with electrical equipment manufacturers. In North America, this unique situation has led to extensive research programs by electric utilities and the use of the facilities of major manufacturerers, their skills, and their experience, to seek answers to problems related to bulk power handling. Problem areas discussed include: line conductors, coronal loss, radio noise, audible noise subconductor vibrations, and--perhaps the area which has received more attention in laboratories than any other--insulation coordination. (Abstract from article)

[1972] IC-013
A PROBABILISTIC APPROACH TO THE EHV LINE INSULATION DESIGN. C. Menemenlis. Canadian Communications & EHV Conference, Montreal, Nov. 9-10, 1972, IEEE publication no. 72 CHO 698-1-REG-7, pp. 103-104. The report outlines the method by which the insulation design is developed on the basis of the reliability requirements. A more specific analysis is made of the influence of both the statistical distribution of the crest value and of the time-to-crest of the overvoltages generated in the system on the reliability of the line. (Abstract from article)

[1972] IC-014
PHASE-TO-PHASE AIR CLEARANCES IN EHV SUBSTATIONS AS REQUIRED BY SWITCHING SURGES. A. Colombo, A. Taschini, G. Sartorio. CIGRE, 1972, paper 33-11. The report examines the electrode configurations of the greatest interest as regards design of phase-to-phase clearances in substations. Then information is given on a series of tests carried out to gain knowledge about the behavior of phase-to-phase air gaps to various types of laboratory impulses. Finally, after an examination of the characteristics of actual switching overvoltages occuring in systems, the authors propose establishment of the values of air clearances in substations. (Abstract from article)

[1972] IC-015
INSULATION LEVELS FOR UHV SYSTEM. L. Paris. IEEE preprint C 72 572-6. The author proposes to open a discussion on the insulation levels foreseeable for UHV systems. To provide a logical support to this discussion, he determines two sets of insulation levels. These are termed reference levels for voltages between 300 and 1500 kV. One set of reference levels refers to unprotected air insulation and the other set to protected internal insulation. The reference values are obtained on the basis of fundamental assumptions which can be considered applicable over the whole range of voltages discussed. The author analyzes the causes of possible deviations from the reference values and reviews the main characteristics of insulation levels in the voltage range from 1000 to 1500 kV. (Abstract from article)

[1972] IC-016
THE OCCURRENCE AND WITHSTAND OF SWITCHING OVERVOLTAGES IN UHV SYSTEMS. D.K. Sweeting, E.G. Maier, W.O. Rowan. Canadian Communications and EHV Conference, Montreal, Quebec, Nov. 9-10, 1972, IEEE publication no. 72 CHO 698-1-REG 7, pp. 105-107. The paper presents calculations of the switching overvoltages to be expected in 1100 kV systems together with their effects on external insulation. (Abstract from article)

[1972] IC-REF
EVOLUTION OF TRANSMISSION SYSTEM IN ITALY AND ADOPTION OF A NEW VOLTAGE LEVEL. L. Paris, F. Reggiani, M. Valtorta. Proceedings, Symposium on Long-Term Prospects of the Electric Power Supply Situation, Stockholm, Sweden, Sept. 11-13, 1972, vol. 2, paper STO/SYMP/EP/E. 7, pp. 1087-1113. For abstract, see entry [1972] PT-013.

[1973] IC-017
REDUCTION OF FAULT CLEARING OVERVOLTAGES BY MEANS OF PRE-INSERTION RESISTORS IN CIRCUIT BREAKERS. A. Ametani. Science and Engineering Review (Japan), vol. 14, no. 3, Dec. 1973, pp. 129-140. Lightning, line energization and re-energization overvoltages have been the primary factors in establishing power system design levels in the past. At 1000 kV and above, line-to-ground voltages produced by fault clearing may be excessive for line insulation designed to lightning limits, since an insulation level of 1.5 per unit or less is expected in the UHV systems. The fault clearing overvoltages can be reduced to corresponding levels by the insertion of resistors in circuit breakers during the opening stroke. The effects of the pre-insertion resistors on fault clearing overvoltages are investigated. It is found that the overvoltages in a given system can be reduced to 1.0 per unit by an appropriate value of the pre-insertion resistors. (IEE abstract, from Inspec)

[1974] IC-018
GENERAL REPORT OF GROUP 33: OVERVOLTAGES AND INSULATION COORDINATION. G. Carrara. Electra (France), no. 37, Dec. 1974, pp. 147-154. The following topics are dealt with: the physical aspect of the electric discharge, both in laboratory (impulses) and in nature (lightning); lightning overvoltages, lightning protection; dielectric strength of external insulation, with particular reference to pollution problems in UHV; control of internal overvoltages, protection against them; application of statistical approach to insulation coordination; and, stresses on UHV surge diverters. (IEE abstract, from Inspec)

[1974] IC-019
TNA IN THE SIMULATION OF POWER SYSTEMS PROBLEMS. P.C. Kalra. Proceedings, 5th Pittsburgh Conference on Modeling and Simulation, Univ. of Pittsburgh, Pennsylvania, April 24-26, 1972, part 2, pp. 639-642. A transient network analyzer (TNA) is a special

purpose analog computer used to study switching surges and other dynamic overvoltages on EHV and UHV power systems. This paper describes the special design features such as transmission line models, etc., used in the McGraw-Edison TNA. (Engineering Index abstract, from Compendex)

[1974] IC-020
SWITCHING IMPULSE BREAKDOWN OF AIR-GAPS WITH APPLICATION TO THE DESIGN OF EHV/UHV EXTERNAL INSULATION. C. Menemenlis, D. McGillis. CIGRE, 1974, paper 33-08. The paper is in two parts. The first deals with the response of air insulation to switching impulses. The effects of the shape of the switching impulse on the 50 percent breakdown voltage and on the standard deviation of the breakdown voltage are analyzed. A new definition for the time-to-crest of the switching impulse is proposed. The second part is an application of the concepts of part one to the design of external insulation using a probabilistic approach to insulation coordination. A simplification of the method is also indicated and a rationalization of insulation levels for EHV and UHV systems is given. (Abstract from article)

[1974] IC-021
PHASE-TO-GROUND AND PHASE-TO-PHASE SWITCHING-SURGE FLASHOVER OF EXTERNAL INSULATION OF UHV STATIONS. H.A. Rohlfs, L.E. Zaffanella. IEEE Transactions, PAS, vol. 93, no. 2, March-April 1974, pp. 518-528. Switching-surge tests were performed on three basic station insulations: horizontal insulator strings, station post insulators, and phase-to-phase air clearances between buses. The influence of different geometrical parameters was investigated. (IEE abstract, from Inspec)

[1974] IC-022
RISK OF FLASHOVER CAUSED BY SWITCHING OVERVOLTAGES IN A COMPLETE UHV SUBSTATION. K.H. Weck. CIGRE, Aug. 1974, paper 23-06. The paper surveys various factors which influence the risk of flashover of a complete substation. Using various approximation methods, an example using a 1300 kV transmission system demonstrates the importance of these factors for calculating risk. The report has two parts. The first deals with switching overvoltages with average mean values and standard deviations of the normal Gaussian overvoltage density taken from the literature assumed for closing operations, single phase faults on the UHV line, clearing of such a fault, and fast 3-phase reclosing. Also considered are the parts of the substations and the number of insulations stressed by the switching overvoltages of the various operations. The second part deals with flashover probability of the insulation, taking into account the influences of the gap distance, the gap configuration, ambient conditions, and switching overvoltage wave shapes. Besides the dielectric strength to ground, that between phases is also considered. (Abstract from article)

[1975] IC-023
LIGHTNING PROTECTION OF 750-1150 kV TRANSMISSION LINES. V.V. Burgsdorf, S.M. Popov. Proceedings of the Symposium on EHV AC Power Transmission, US-USSR committee, Feb. 17-27, 1975, Washington, D.C., pp. 126-150, published by Bonneville Power Administration. The paper addresses lightning protection of both lines and substations and concludes: (1) reliability for lines can be very high especially with reduction of safety angles from 20 percent to 10 percent; (2) calculations of protection for substations must consider step nature of lightning wave, effect of operating voltage, and slower deformation of front of impulse waves; (3) dangers at EHV substations comes primarily from lightning waves caused by subsequent impulses of lightning discharge; and, (4) coordination intervals of 40 percent dangerous lightning overvoltages at a substation might occur once in 3000 years for 20 storm hours and diminishing the interval to 25 percent sharply reduces system reliability. (Abstract from article)

[1975] IC-024
LIGHTNING PROTECTION OF UHV TRANSMISSION LINES. M. Darveniza, F. Popolansky, E.R. Whitehead. Electra, no. 41, 1975, pp. 39-69. This report presents concepts of lightning protection systems for UHV transmission lines and preliminary estimates of lightning outage rates developed from recent studies for CIGRE working group 33.01. It was not thought feasible, or even desirable, to attempt to reach a unified point of view on the many aspects of the subject at this time. The several contributions were therefore integrated, with some conclusions developed, and some uncertainties identified. Areas addressed include conceptual designs for UHV lines, mechanisms of lightning flashover, frequency distributions of lightning current amplitudes, shielding system design, backflash protection system design, and estimates of lightning performance of UHV lines. Three major areas of uncertainty emerge from the study: (1) the effect of shield wire and tower height on the number of strokes collected by the line; (2) the striking distance or attractive range; and, (3) the possibility of phase-to-phase faults resulting from shielding failures caused by strokes of sub-critical prospective current. (Abstract from article)

[1975] IC-026
PROGRESS REPORT OF STUDY COMMITTEE NO. 33: OVERVOLTAGES AND INSULATION CO-ORDINATION. V. Palva. Electra, no. 40, May 1975, pp. 33-44. The following topics are dealt with: (1) lightning and discharge phenomena; lightning overvoltages and lightning overvoltage protection; (2) dielectric strength of the external insulation; validity of test results; pollution problems at UHV; (3) control of internal overvoltages and internal overvoltage protection (except the influence of the circuit-brakers); and, (4) application of the statistical approach to insulation coordination; stresses on UHV surge diverters. (IEE abstract, from Inspec)

[1975] IC-027
BASIC PRINCIPLES FOR SWITCHING SURGE AND LIGHTNING PROTECTION. F.S. Young. Proceedings of the Symposium on EHV AC Power Transmission, US-USSR committee, Feb. 17-27, 1975, Washington, D.C., pp. 115-125, published by Bonneville Power Administration. The design of UHV transmission systems is complex and difficult, and reliable operation is essential. Most challenging is the effective control of transient overvoltages generated by switching transmission lines. The design of UHV transmission systems has been based on the principle of limiting switching surge voltages to levels approaching 1.5 per unit. Studies made to evaluate the effectiveness of the various concepts applicable to this objective are the subject of this paper. (Abstract from article)

[1975] IC-028
THE ELECTRICAL WITHSTAND STRENGTH OF LARGE AIR GAPS AND SELECTION OF AIR INSULATION CLEARANCES ON TRANSMISSION LINES; SELECTION OF LINE AND SUBSTATION INSULATION IN CLEAN AND CONTAMINATED ENVIRONMENTS. F.S. Young. Proceedings of the Symposium on EHV AC Power Transmission, US-USSR committee, Feb. 17-27, 1975 Washington, D.C., published by Bonneville Power Administration, pp. 180-202. Research related to the behavior of insulaton of high-voltage power systems is perhaps one of the best documented areas of electrical engineering. Yet the ultimate solution has not been discovered. This paper summarizes the latest in two areas of transmission line design: (1) selection of line and substation insulation in clean and contaminated environments, and the electrical withstand strengths of large air gaps; and, (2) selection of air insulation clearances on transmission lines. Included is the text of a paper by the IEEE working group on insulator switching surges which discusses switching surge strength of transmission line insulation. (Abstract from article)

[1975] IC-REF
GENERATION OF SWITCHING IMPULSES USING HIGH VOLTAGE TESTING TRANSFORMERS. H. Anis, N. Trinh, D. Train. IEEE Transactions, PAS, vol. 94, no. 2, March-April 1975, pp. 187-197. For abstract, see entry [1975] TF-010.

[1976] IC-029
GENERAL REPORT OF GROUP 33: OVERVOLTAGES AND INSULATION COORDINATION. G. Carrara. Electra, no. 49, December 1976, pp. 117-123. The subjects discussed include: the stresses imposed on EHV and UHV surge arresters and the test methods; phase-to-phase and longitudinal insulation; and the problems of insulation coordination in SF6 substations. (IEE abstract, from Inspec)

[1976] IC-030
GENERAL REPORT OF GROUP 15: INSULATING MATERIALS. T.W. Dakin. Electra, no. 49, Dec. 1976, pp. 75-82. The subjects discussed include: combined voltage, temperature and mechanical stress effects on the life of solid insulation; progress in liquid dielectrics (hydrocarbon types, synthetic products, etc.); and, properties of HV and UHV (compressed) gas-insulated structures. (IEE abstract, from Inspec)

[1976] IC-031
EFFECT OF EXTRANEOUS ELECTRIC FIELDS ON ERROR IN DETERMINING HIGH-VOLTAGE INSULATION DIELECTRIC CHARACTERISTICS. M.V. Lokshin. Elektrichestvo (USSR), no. 1, 1976, pp. 36-43, translated in Electric Technology USSR (U.K.), no. 1, 1976, pp. 12-28. A study of determination of tan delta and Cx prompts recommendations for an improved method which is applied to the insulation of bushings and current transformers at 110-500 kV to 1150 kV. (IEE abstract, from Inspec)

[1976] IC-032
INFLUENCE OF PRESTRIKE ON THE PEAK VALUES OF ENERGISATION TRANSIENTS. O.H. Svensen. IEEE Transactions, PAS, vol. 95, no. 2, March-April 1976, pp. 711-720. It is shown that due to prestrike the closing instants of a circuit breaker will have a non-uniform statistical distribution and that the influence on the peak overvoltage distribution is significant. The voltage-drop across the circuit breaker in the prestrike period has been considered and a better agreement between field test oscillograms and calculated transients is obtained when this voltage-drop is accounted for. (Engineering Index abstract, from Compendex)

[1977] IC-033
GAS-INSULATED SUBSTATION EQUIPMENT FOR UHV PROBLEMS AND NEEDS. R.W. Flugum, T.F. Garrity, J.P. Vora. World Electrotechnical Congress, Moscow, June 1977, section 2, paper 67. Another step in transmission voltage above 800 kV appears necessary if large concentrations of generation continue to be located at sites remote from load centers. Also evident, from 1200 kV test stations in operation and under construction, is that substations for these voltages will be gas insulated because of size and height considerations. Although many lower voltage gas substations are in service, most of the equipment in these stations is similar to equipment used in outdoor air-insulated installations and, as such, is not optimized for use in a gas environment. Design changes, most of them departures from conventional practices, are necessary. This approach will result in maximizing the environmental advantages possible, thus the transition from air to gas will be complete and involve the entire station.

[1977] IC-034
UHV: ONWARD AND UPWARD. G.D. Friendland. IEEE Spectrum, Feb. 1977, pp. 56-65. The article describes the major research and development efforts in the USA and abroad to push practical transmission above the 1000 kV level. (Abstract from article)

[1977] IC-035
RESEARCH AND DEVELOPMENT. J.G. Harlow, Jr. Electrical Power Systems Research, vol. 1, no. 1, Sept. 1977, pp. 1-7. This article reviews the results for the electric utility industry of past R&D such as substituting aluminium for copper conductors, reducing site requirements with new structural shapes, improved lightning protection and relay protection, high-speed control and protection of power systems including computer applications, the development of EHV and UHV transmission systems, the digital Supervisory Control and Data Acquisition (SCADA) system for improved monitoring and loading. Although these measures will help provide low-cost dependable electricity in the future, much remains to be done, such as improving load forecasting and reliability analysis, designing and applying gas-insulated metal-enclosed minisubstations, finding materials to substitute for increasingly expensive structural steel, and providing means for handling increasing load densities in urban areas. The future energy needs of the world can only be supplied through technological improvements. The cost of these technological improvements can be minimized by cooperative, unified R&D programs. The financial support of the energy industry, the equipment manufacturing industry and the consumer will be required to finance these vital developments. (Engineering Index abstract, from Compendex)

[1977] IC-036
RATES AND METHODS FOR TESTING THE WITHSTAND STRENGTH OF THE INSULATION OF 1150 kV AC PROTOTYPE ELECTRICAL EQUIPMENT. A.K. Lokhanin. Proceedings, Vsesouznii Elektrotechnicheskii Institut (V.I. Lenin's All-Union Electrotechnical Institute, USSR), 1977, issue 85. (Abstract unavailable)

[1977] IC-037
INSULATION PROBLEMS IN UHV TRANSMISSION SYSTEMS. M. Sforzini, A. Taschini, G. Carrara, A. Clerici. World Electrotechnical Congress, Moscow, June 1977, section 2, paper 13. The report deals with the problems posed by the choice of insulation in UHV systems, in particular of the phase-to-ground insulation in overhead power lines. The air clearances necessary for the flashover risk to be below a pre-established value are given under different assumptions of overvoltage control. A statistical approach is also presented for the insulator strings design under polluted conditions. (Abstract from article)

[1977] IC-REF
A PROGRAM FOR UHV TRANSMISSION. H.N. Scherer, Jr., B.J. Ware, H.B. Thoren. American Power Conference Proceedings, vol. 39, 1977, pp. 1113-1120. For abstract, see entry [1977] SA-007.

[1978] IC-038
EVALUATION OF THE RISK OF FAILURE DUE TO SWITCHING SURGES IN UHV NETWORKS. G. Borgonovo, G. Santagostino, G. Cambelli, L. Lagostena, A. Porrino. CIGRE, 1978, paper 33-14. This paper discusses the problems of switching-surge overvoltages and their impact on UHV systems. Special attention is given to possible means for their limitation. Considerable calculations have been performed to determine the levels of switching surge overvoltages generated under various conditions (fault application, single-phase and three-phase reclosure, line energization, etc.) with respect to some possible layouts of the future UHV Italian network. Proceeding from the calculated overvoltages, the risk of insulation failure of the line has been determined for different values of 50 percent discharge voltage of tower insulation to switching impulse. The paper also gives some information concerning the project of the future UHV system, in particular as regards the use of opening and closing resistors, earth-breakers, single or 3-phase reclosure, and shunt reactors. (Engineering Index abstract, from Compendex)

[1978] IC-039
UHV DISCONNECTORS: SWITCHING SURGE DESIGN AND TESTING OF EXTERNAL INSULATION. G. Carrara, A. Pigini, M. Polo-Dimel. IEEE Transactions, PAS, vol. 97, no. 6, Nov.-Dec. 1978, pp. 2094-2103. The switching surge insulation characteristics of a disconnector (formerly 'switch') are presented in a generalized form. Based on a series of tests performed on UHV disconnectors with various heights and clearances between contracts. The knowledge of these characteristics and of the distribution of the expected overvoltages in service allows determination of the total risk of discharge and the risk of discharge across the longitudinal insulation. A general method for the design of a disconnector that meets prescribed maximum tolerable risks is presented. The statistical significance of a type test is then investigated, and the procedures recommended by IEC and IEEE are criticized. Some changes in the testing procedure are finally proposed, to ameliorate the tests and to reduce the differences between their requirements on the design of a disconnector. (IEE abstract, from Inspec)

[1978] IC-040
HIGH-VOLTAGE PERFORMANCE OF MIXTURES OF SF6 WITH N2, AIR AND CO2 IN COMPRESSED-GAS-INSULATED EQUIPMENT. A.H. Cookson, B.O. Pedersen. IEE Conference Publication no. 165, 1978, pp. 161-164. Compressed SF6 is used for the high voltage insulation in compressed-gas-insulated transmission lines

(CGIT) and gas-insulated substations, typically at a pressure of 0.45 MPa. As part of a program for the development of a 1200 kV CGIT system, an investigation has been made of the breakdown characteristics of mixtures of SF6 with nitrogen, air and carbon dioxide, specifically for assessing the potential use in CGIT lines. Although there have been many previous studies of these mixtures--particularly for SF6 and nitrogen--no comprehensive studies have been reported for a practical size electrode system with all the test voltage waveforms that must be used with transmission systems, i.e., ac, lightning impulse and switching impulse. These tests are required to ensure that the insulation coordination is not adversely affected in the mixture. (Engineering Index abstract, from Compendex)

[1978] IC-041
1 km UHV TEST LINE: PRELIMINARY PHASE-TO-PHASE SWITCHING IMPULSE TESTS. R. Cortina, A. Taschini, G. Carrara, L. Thione. CIGRE, 1978, paper 33-15. The paper reports on a preliminary series of phase-to-phase switching impulse tests performed in summer 1977 on the 1 km test line in the UHV experimental station in Suvereto. The line consisted of a central span 510 meters long with two 60-meter towers and two terminal half spans of 250 meters. The line was equipped with two bundles of 6 and 8 subconductors. Phase-to-phase tests were carried out on the conductor-conductor configuration with clearances between 7 and 16 meters. An investigation was made of various factors: the distribution of the voltage between the two phases, the time to crest of the positive impulse, the time shift between the crests of the negative and positive impulses, and the height of the conductors above the ground plane. The paper outlines preliminary test results and compares these with similar data for conductors of shorter length. (Abstract from article)

[1978] IC-042
MODELING UHV NETWORK TRANSFORMERS IN TRANSIENT MODE (in French). Ph. Auriol. Proceedings, Canadian Communications Power Conference, Montreal, Canada, Oct. 18-20, 1978, IEEE conference publication no. 78 CH 1373-0-REG-7, pp. 520-523. A digital simulation method is presented taking into account a considerable number of lines and busbars. Further, a 3-phase transformer is modeled, and the model is introduced into sampled data network equations. The nonlinear system thus derived is solved by the Newton-Raphson type method, which ensures reliability and low cost. (Engineering Index abstract, from Compendex)

[1978] IC-043
LYONS 1100/1200 kV SUBSTATION TASK FORCE QUARTERLY REPORT: APRIL 1, 1978-JUNE 30, 1978. K.M. Watkins. 1200 kV Prototype Transmission Line Project. Bonneville Power Administration, Portland, Oregon. Along with a function description of the task force are materials on 1) estimate for contained gas-insulated (CGI) 1200 kV bus with a preliminary station layout; and, 2) information on U.S. Department of Energy contract with Westinghouse on the development of semi-flexible UHV CGI cable. In the latter, work has focused on the corrugated "culvert" sheath and flexible conductor designs. (Abstract from report)

[1978] IC-REF
ELECTRIC STRENGTH OF SUPPORT INSULATION OF UHV 330-1150 kV CIRCUIT BREAKERS. L.S. Slutskin. Electric Technology USSR (U.K.), no. 4, 1978, pp. 23-33. For abstract, see entry [1978] SW-041.

[1979] IC-044
PHASE-TO-PHASE INSULATION COORDINATION. CIGRE study committee 33. Electra, no. 64, May 1979, pp. 137-230. Close cooperation between the CIGRE working group and IEC's group 28 results in the publication of four companion pieces describing the latest stage of knowledge in the field of standardization work for phase-to-phase insulation coordination. The four segments deal with the switching overvoltage situation in the networks; the switching impulse strength of external insulations; the design criteria for and the testing technique of phase-to-phase insulations; and the influences of non-standard conditions on the dielectric strength. Included is an evaluation guide of overvoltages which intends to standardize the evaluation of oscillograms recorded, and standardize determination of overvoltages and overvoltage factors. (Abstract from article)

[1979] IC-045
BPA 1100 kV TRANSMISSION SYSTEM DEVELOPMENT: INSULATION STUDIES. C.L. Nellis, E.J. Yasuda, R.L. Brown. IEEE Transactions, PAS, vol. 98, no. 4, July-Aug. 1979, p. 1142, abstract only. Published in IEEE publication no. 79TH09057-0-PWR, pp. 30-38. Insulation study objectives and initial results from BPA's 1100 kV transmission system development project are outlined. Included are transient analyzer results, design criteria, field performance, and laboratory 60 Hz and switching impulse tests on the full-scale tower window insulator assembly. (Abstract from article)

[1979] IC-046
A STUDY TO INVESTIGATE THE BASIC SWITCHING IMPULSE INSULATION LEVEL REQUIREMENTS FOR A 1200 kV CGIT SYSTEM. R. Pfleiderer. U.S. Department of Energy, DOE/ET-2061-2, July 1979. A study was performed to determine the switching surge voltages a prototype 1200 kV CGIT cable may be exposed to under service conditions. The results of this study were used to establish the system's basic switching impulse insulation level requirements. An investigation was made of a suitable CGIT model to be employed for use on the Westinghouse transient network analyzer.

The model chosen was applicable for the cable when its sheaths are solidly grounded. This model was employed for each of the four cable lengths investigated. Cable lengths of 600 feet, 2 miles, 10 miles and 50 miles were investigated in four general system configurations, in all 47 systems were studied. The overhead systems with which the cables will be used require the switching surge voltage to be limited to 1.5 per unit, accomplished with multi-resistor insertion circuit breakers. The maximum normal switching surge overvoltage the cables were subjected to was 1574 kV which resulted from high speed reclosing operations. The maximum overvoltages resulting from the contingency switching operation were 2165 kV. The recommended switching impulse insulation level--established using the surge arrester protection characteristics--is 2031 kV based upon the use of a conventional surge arrester and 1806 kV based upon the use of a ceramic oxide arrester. (Abstract from report)

[1979] IC-047

LIMITING VALUES OF CRITICAL ELECTRIC STRESS AND THE DESIGN PREDICTION OF EHV/UHV SF6 INSULATION BREAKDOWN. K. R. Spriggs. IEEE Transactions, EI, vol. 14, no. 3, June 1979, pp. 142-147. Analysis of SF6 Paschen curves in the EHV/UHV range has been made. It is observed that the limiting value of critical electric stress is not the stress at which the apparent ionization and attachment coefficients are equal; that is, it is not the limiting value found for lower voltage treatment. Paschen departures, concluded to be a genuine phenomenon, are found to occur as a hyperbolic function of gap spacing. The Paschen curve, including departures, yields two new values of limiting critical stress. From these values, an equation is developed which may be used to predict insulation breakdown in uniform field configurations. Using a field intensification factor, the equation is adapted to the important engineering configuration of coaxial cylinders. The resultant equation gives good correlation with the breakdown behavior found by several groups using differing electrode geometries. Prediction of breakdown voltage is more accurate than that obtained by the widely used law of similarity. The breakdown equation is in a form suitable for use in prediction of EHV/UHV SF6 breakdown in engineering insulation design situations. (Abstract from article)

[1979] IC-REF

STUDY TO DETERMINE THE BASIC INSULATION LEVEL REQUIREMENTS FOR A PROTOTYPE 1200 kV CGIT CABLE SYSTEM. J.H. Cooper. Advanced Systems Technology Division, Westinghouse Electric Corp., Pittsburgh, Pennsylvania. DOE/ET 2061-1, contract no. EX-76-C-01-2061, July 1979. Available from NTIS. For abstract, see entry [1979] SA-016.

[1980] IC-048

THE ELECTRICAL STRENGTH OF LONG AIR GAPS OF UHV INSULATION STRUCTURES. G.N. Aleksandrov, V.L. Ivanov, V.S. Kindiakov, G.T. Kitaev, L.S. Slutskin, O.V. Volkova. CIGRE, 1980, paper 33-05. The results of electrical strength investigations on UHV insulation structures carried out in some UHV outdoor and indoor laboratories in the USSR are given. The interrelation between the electrical strength and test impulse form is considered. The report discusses the possibility of increasing the electrical strength of the UHV outdoor insulation structures. (Abstract from article)

[1980] IC-049

PHASE-TO-PHASE AND PHASE-TO-EARTH RISK OF FAILURE DUE TO SWITCHING SURGES IN UHV SYSTEMS. N. Fiorella, G. Santagostino, L. Lagostena, A. Porrino. CIGRE, 1980, paper 33-12. The report deals with problems of insulation coordination under switching surges, with reference to UHV transmission lines, for both conventional and unconventional design. The phase-to-phase and phase-to-earth risk of discharge is calculated with reference to more critical operations, such as energization, single and 3-phase reclosing and opening. Both phase-to-earth and phase-to-phase faults are considered. In the first case single-pole switching is assumed. The minimum phase-structure and phase-to-phase clearances are determined on the basis of the previous calculations to reduce the breakdown risks to acceptable values. (Abstract from article)

[1980] IC-050

OVERVOLTAGE PROTECTION AND INSULATION COORDINATION OF GAS-INSULATED SUBSTATIONS. A. Schei. Proceedings, The Brown Boveri Symposium: Surges in High-Voltage Networks, Baden, Switzerland, Sept. 3-4, 1979, published in Surges in High-Voltage Networks, Plenum, N.Y., 1980, pp. 345-504. Editor: K. Ragaller. From the overvoltage protection and insulation coordination point of view, lightning overvoltages are the most difficult ones to tackle. High overvoltages in GIS are caused by close backflashovers and are a result of a close interaction between the line(s) and the GIS itself. The mean voltage steepness within a 275 kV GIS connected to a shielded overhead line varies from 750 kV MUS at the entrance to 1200 kV/MUS at the transformer. The corresponding maximum steepnesses are 1000 and 2000 kV/MUS, respectively. Surge arresters, metal-oxide arresters and spark gaps are possible means to limit overvoltages in GIS. With the same nominal protection level, the metal-oxide arrester gives lower overvoltages and consequently lower risk of failure than the surge arrester and the spark gap, mainly because it conducts a rather high current at voltages far below the nominal protection level. The lack of sparkover transient is also a benefit. Spark gaps give the highest overvoltages and overinsulation seems necessary. GIS protected against lightning overvoltages by means of surge arresters will normally also be well protected against switching overvoltages. The length of the connection that leads to the arrester--as well as the length of line between the arrester and the GIS--are found to be critical and should be as short as possible. Due to their negligible lead length and location inside the GIS, enclosed

arresters have considerable technical advantages. The crest value as well as the steepness of lightning overvoltages in GIS vary considerably from position to position in the station. The voltage-time withstand characteristic for the various items of equipment at different locations should therefore be considered. A capacitor at the entrance to the GIS reduces the steepness and the crest value of the overvoltages, thus reducing the risk of failure. (IEE abstract, from Inspec)

[1980] IC-051
1200 kV SUBSTATION TASK FORCE QUARTERLY REPORT, JANUARY 1, 1980 - MARCH 31, 1980. G.W. VanGinhoven. 1200 kV Prototype Transmission Line Project, quarterly report 14, March 31, 1980. Bonneville Power Administration, Portland, Oregon. Initial plans have been developed to design a 1200 kV substation at the Marion Substation site. The initial plan shows one line in with a bank and low side power circuit breaker. Second stage shows two lines, two 100/500 kV banks and a 2-bay one-and-one-half power circuit breaker GIS. A list of SF6 apparatus to be installed at Lyons has been prepared. Most of the apparatus will be available from the DOE-UHV-SF6 test program being performed at Waltz Mill, Pennsylvania. Equipment should become available in late 1982 provided the present Waltz Mill test program is completed on schedule. (Abstract from report)

[1980] IC-052
ALLOWING FOR NON-EQUIPOTENTIALITY OF EARTHINGS IN CALCULATING THEIR ELECTRIC PARAMETERS. A.I. Yakobs, T.T. Konobeeva. Electric Technology USSR (U.K.), no. 1, 1980, pp.165-168. The article considers how to allow for the self-longitudinal resistance of horizontal parts of complex earthings for transformer substations and distribution gear at 330-1150 kV. New theory is based on the theory of nonlinear circuits with distributed parameters. A prime consideration now is the permissible contact voltage. Error in the earlier method is estimated with regard to currents at raised frequencies. An interative algorithm for calculating leakage conductance by two models indicates nine to 60 percent error. (Engineering Index abstract, from Compendex)

[1980] IC-REF
THE FUTURE TESTING NEEDS OF GAS-INSULATED SUBSTATIONS. T.F. Garrity, J.P. Vora. 2nd International Symposium on Gaseous Dielectrics, March 1980, p. 389f. (Main entry [1980] TF-009, abstract unavailable)

[1980] IC-REF
FUNDAMENTAL RESEARCH INTO HIGH VOLTAGES FOR FURTHER DEVELOPMENT OF ELECTRIC POWER DISTRIBUTION SYSTEMS. E.Gockenbach, W. Buch, M. Crucius, A. Diessner, H. Luehrmann. A.G. Siemens, Berlin, Germany, report BMFT-FB-T-82-064: ISSN-0340-7608, Dec. 1980. Available from NTIS. For abstract, see entry [1980] TF-015.

[1980] IC-REF
DESIGN AND APPLICATION OF BREAKERS BASED ON LATEST DEVELOPMENTS. A. Leibold, A. Eidinger. IEEE conference publication no. 79 CH1399-5-PWR, 1980, pp. 355-360. For abstract, see entry [1980] SW-044.

[1981] IC-053
HVAC INSTRUMENT SYSTEM FOR GAS-INSULATED COAXIAL LINES, FINAL REPORT. G.J. Carlson, F.A. Fisher, J.M. Houston, R. Nakata, D.C. Peroutky. General Electric Corporate Research and Development, Schenectady, N.Y., Oct. 1981, report DOE/ET/29661-1. This program was conducted for the development of metering quality, 0.3 percent accuracy class, current, and voltage instrumentation for an advanced 1200 kV, as gas-insulated power transmission system. This instrumentation is designed and uniquely adapted to the geometry of the coaxial line. The physical objective of the program is a test section of 1200 kV coaxial gas bus containing prototype instruments for measuring line current (1 per unit = 3000 A. 60 Hz), line voltage (1 per unit = 693 kV, 60 Hz line-to-ground) and for injection and receiving carrier power (about 10W) at frequencies typically in the 100 kHz to 500 kHz range. In addition to a metering specification, current and voltage instrumentation must respond to transient conditions with sufficient bandwidth (about 5 kHz) for use in protective relaying or measuring fault transients. The design fabrication and testing of the measuring instruments and associated electronic equipment for signal amplification are described. Test results indicate the system will meet the requirements of both revenue metering, 0.3 percent class, and protective relaying. Outputs of the signal amplifier channels are typically 3 to 5 V rms at normal line power and are suitable for metering or driving static relays and other low-load-burden (2000 ohm) devices. Initial field tests are planned at the EPRI Waltz Mill Cable Testing Facility, near Pittsburgh, Pennsylvania. (NTIS abstract)

[1981] IC-054
AC FLASHOVER CHARACTERISTICS OF LONG AIR GAPS AND INSULATOR STRINGS UNDER FOG CONDITIONS. K. Takasu, N. Aria, Y. Imano, T. Shindo, T. Seta. IEEE Transactions, PAS, vol. 100, no. 2, Feb. 1981, pp. 639-645. This paper describes the ac flashover test results of long air gaps up to 8 meters and insulator strings under fog conditions, obtained in the new UHV fog room completed in February 1979 at Takeyama Laboratory of Central Research Institute in Tokyo, Japan. In the fog room, steam fog is generated by two boilers, and a 900 kV, 2000 kVA testing transformer was used to generate the test voltage. The withstand voltages of a rod-plane gap and rod-rod gap under fog conditions showed considerable decreases as compared with the flashover

voltages under dry conditions. (IEE abstract, from Inspec)

[1981] IC-055
AIR INSULATION DESIGN OF UHV STATIONS BASED ON SWITCHING SURGES. C. Menemenlis, G. Harbec, A. Hould, B. R. Shperling, W. Pokorny, S. Zelinger. IEEE Transactions, PAS, vol. 100, no. 2, Feb. 1981, pp. 891-898. Switching impulse tests were performed on large air gaps to determine the insulation strength of future UHV stations. Rigid buses, both suspended and post insulator supported, were tested for heights up to 15 meters. Phase-to-phase arrangements were tested by simulating substation configurations. This includes horizontal crossed buses and the ring-to-bus configuration of parallel buses, for interphase clearances up to 16 meters. This study also included the effects of other factors, such as wave shape, bus size, shape of ground support structures, and proximity effects. (Abstract from article)

[1982] IC-056
A PROBABILISTIC APPROACH IN ESTIMATING THE BIL FOR 1200 kV GAS-INSULATED STATIONS. J.H. Cooper, A.R. Hileman. CIGRE, 1982, paper 33-02. Also available from Bonneville Power Administration in Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, 1982, pp. 328-333. A study was performed to estimate the required basic lightning impulse insulation level (BIL) of prototype 1200 kV stations. The methodology developed consisted of (1) determining the limiting value of the parameters of the incoming surge which produces crest surge voltages within the station equal to an assumed BIL, and (2) determining the probability that the incoming surge will possess parameters equal to or greater than these lightning parameters. The required BIL ranges from 1925 to 2300 kV depending on the assumptions. A BIL of 2175 kV was selected.

[1982] IC-057
DESIGN OF SYSTEMS FOR PROTECTION AGAINST OVERVOLTAGES FOR 1200 kV AC POWER LINES WITH THE AIM OF LIMITING OVERVOLTAGES TO 1.3, 1.5, and 1.8 p.u. V.E. Davydov, I.E. Efremov, M.L. Levinshtein, Yu.I. Lyskov, V.N. Pod'yachev, F.Z. Khakimov. Third Symposium on EHVAC Power Transmission, US-USSR joint committee, published by Bonneville Power Administration, May 10, 1982, pp. 177-3-04. The purpose of the studies is to establish the characteristics of overvoltages occurring on substation and line insulation when clearing emergencies due to single-phase short circuiting on overhead lines by means of 1-phase automatic reclosure. The authors examine two main power transmission circuits, which differ from one another in the absence of presence of power lines of the 1150 kV class branching from the buses of receiving and sending systems. (Abstract from article)

[1982] IC-058
FAULT LOCATION SYSTEM FOR TRANSMISSION-TYPE CABLE. H.E. Gallagher, D.R. Mize, A.F. Dickerson. IEEE Transactions, PAS, vol. 101, no. 6, June 1982, pp. 1700-1710. A fault location system was developed for locating nonlinear faults on transmission-type cable. The fault locator measures the distance from terminal to fault as a fraction of the total cable length. A forward wave radar principle is used. The forward wave is generated by the cable breakdown at the fault. Laboratory and field tests indicate that nonlinear faults can be located to within + 10 meters. Equipment modifications have been made to measure cable lengths to 10 km or longer. Further field tests and demonstration tests are planned. (Abstract from article)

[1982] IC-059
INSULATION COORDINATION FOR UHV SUBSTATIONS. L. Lagostena, A. Porrino. Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 236-244. Available from Bonneville Power Administration. The paper describes studies performed to define BIL and SIL of UHV substations, with particular reference to SF6 solution. Lightning and switching surges have been calculated--with reference to some possible layouts for the future UHV Italian network--with the help of digital or TNA simulations. (Abstract from article)

[1982] IC-063
DEVELOPMENT OF AN OVERVOLTAGE PROTECTIVE SYSTEM FOR 1200 kV AC TRANSMISSION WITH THE INTENT OF LIMITING OVERVOLTAGES TO 1.3, 1.5, AND 1.8 PER UNIT. F.G. Schaufelberger, L.E. Zaffanella, L.A. Kilar. Third Symposium on EHVAC Power Transmission, US-USSR joint committee, published by Bonneville Power Administration, May 10, 1982, pp. 144-176. This report presents results of investigations which continue previous work by the US and USSR. The USA has performed additional work as recommended at the 1978 Tashkent symposium. These tests--of switching overvoltages caused by fault clearing with near simultaneous opening of the power circuit breakers at each end of the line and by near simultaneous reclosing of these breakers--are similar to those already described by the USSR group. Conclusions included the following: (1) Overvoltages produced by 3-phase reclosure did no exceed 1.5 per unit for the load angles of 60 electrical degrees or less. (2) Single-phase reclosures did not produce overvoltages which exceeded 1.5 per unit for same load angles. (3) Line-to-ground voltages are limited to 1.35 per unit when the PCBs are opened almost simultaneously in clearing symmetrical faults when the PCBs are equipped with 400 ohm opening resistors. (4) System overvoltage can reach 2.0 per unit with 400-ohm opening resistors when clearing symmetrical faults, if the load angle is 90 degrees. The report details these and other findings. (Abstract from article)

[1982] IC-064
INTEGRATED 1100-1150 kV BUS-AND-SWITCH STRUCTURES WITH SULFUR HEXAFLUORIDE INSULATION (CURRENT STATE AND FUTURE PROSPECTS). Yu.I. Vishnevskii, V.K. Tarasov, V.N. Borin, B.S. Chemeris. Soviet Electrical Engineering, vol. 53, no. 6, 1982, pp. 13-20. The advantages of integrated bus-and-switch structures using SF6 insulation over conventional equipment together with construction of and test results for soviet installations of this type are discussed; a technical economic comparison with similar foreign apparatus is given. (Engineering Index abstract, from Compendex)

[1982] IC-068
JOINT USA-USSR INVESTIGATIONS OF SWITCHING IMPULSE CHARACTERISTICS OF LINE INSULATION IN A WIDE RANGE OF TIMES TO CREST. L.E. Zaffanella, K.J. Lloyd. Third Symposium on EHVAC Power Transmission, US-USSR joint committee, published by Bonneville Power Administration, May 10, 1982, pp. 91-108. The joint US-USSR investigations carried out in 1977 produced the switching impulse strength of rod-plane and tower air gaps and insulator strings for a comprehensive number of times to crest. Tests were made with times to crest from 90 μs to 1200 μs in the USA and from 1800 μs to 6200 μs in the USSR. Continuation of the joint program consists of each side completing tests in the whole range of times to crest. This report describes ranges from 1000 μs to 3000 μs performed in the USA. Rod-plane and tower air gaps were tested using a cascade of two transformers of the Project UHV test line and applying an impulse to the test line. Tests were performed in two different periods of the year to determine the effect of atmospheric conditions. Special efforts were made to determine the standard deviation of the flashover voltage. (Abstract from article)

[1982] IC-069
EVALUATION, DESIGN, DEVELOPMENT, AND DELIVERY OF A 1200 kV PROTOTYPE TERMINATION. J.S. Billings, J.R. Meyer. Eleventh Technical Progress Report, June 1, 1981-Feb. 28, 1982. Westinghouse Electric Corp. Report no. DOE/ET/29068-T7, April 1982. Final results and conclusions are reported on the mechanical model studies. Bend strength of reinforced epoxy bars before and after thermal cycling is compared. Tooling for the cast epoxy insulators was designed and component parts and tooling for the full-scale prototype were ordered. (NTIS abstract)

[1982] IC-REF
DEVELOPMENT OF EHV TRANSFORMERS BASED ON UHV TECHNIQUE. E. Mori, M. Hoshi. Hitachi Review, vol. 31, no. 3, June 1982, pp.147-150. For abstract, see entry [1982] PT-052.

[1982] IC-REF
TESTING FACILITIES FOR DEVELOPING UHV EQUIPMENTS. M. Yamamoto, M. Honda. IEEE Transactions, PAS, vol. 101, no. 7, July 1982, pp. 2314-2318. For abstract, see entry [1982] TF-013.

[1982] IC-REF
INSULATION COORDINATION OF 1200 kV SYSTEMS WITH THE GAPLESS 1200 kV METAL OXIDE SURGE ARRESTER. A. Hileman, A. Sweetana, N. Hingorani, V. Tahiliani. Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 334-354. For abstract, see entry [1983] SA-029.

[1983] IC-071
SF6 GAS-INSULATED METALCLAD SUBSTATIONS: 800 kV SERVICE EXPERIENCE, PROSPECTS FOR 1200-1600 kV RATINGS. F. Le Maux, G. Voisin. Proceedings, CESI Symposium 1983. The technique of metalclad GIS has widely evidenced its efficiency up to 800 kV. Now 17 years old, this technique is still full of promises and it seems very fit to meet UHV requirements. This evolution requires, in addition to the continuous development of research, the fulfilment of three conditions: (1) adaptation of manufacturing processes and facilities to more and more bulky components (the reduction of surface area due to the metalclad technique is all the more appreciated by the user as the system voltage increases, but such is not the case at the manufacturer's); (2) adaptation of laboratory and site testing facilities to the scale of the switchgear performances; and, (3) development of a close cooperation between users and manufacturers. This article cites material on facilities at several sites. (Abstract from article)

[1983] IC-REF
PROBLEMS OF LONG-TERM RELIABILITY FOR UHV TRANSFORMER INSULATION. T. Yanari, M. Honda, M. Ikeda, Y. Taniguchi, Y. Ebisawa. IEEE Transactions, PAS, vol. 102, no. 6, June 1983, pp. 1693-1701. For abstract, see entry [1983] PT-054.

[1984] IC-REF
TESTING OF A 1100 kV, 3 TO 9 GVA UNDERGROUND TRANSMISSION SYSTEM. F. Farneti, P. Menesatti, E. Dotti, G. Luoni. IEEE winter meeting, 1984, paper 190-5. For abstract, see entry [1984] TF-017.

[1968] SW-001
SWITCHGEAR WITHOUT BATTERY (in Czech). J. Bermann. Mereni A Regulace, vol. 16, no. 3-4, 1968, pp. 93-97. The proved protections, operating without auxiliary voltage are described. The difficulties with the current supply for the tripping coil of the power circuit breaker and the solving of these difficulties by means of a capacitor source are mentioned. The devices supplied by current or voltage, and their use in HV or UHV switchgear, are also treated. (IEE abstract, from Inspec)

[1969] SW-003
DESIGN AND APPLICATION OF EHV AND UHV VERTICAL BREAK AND VERTICAL REACH SWITCHES. A. Foti, R.F. Swoish, E. Gorin. IEEE Transactions, PAS, vol. 88, no. 5, May 1969, pp. 709-719. This paper discusses the design and application of EHV and UHV disconnecting switches. It reports on the results of comprehensive electrical and mechanical tests conducted on 765 kV vertical break and vertical reach switches. Electrical clearances, both line-to-ground and line-to-line, are reviewed. Finally, statements are made concerning 1100 kV switch designs in view of possible reduction in switching surge impulse levels from 2.1 to 1.5 per unit. (Abstract from article)

[1969] SW-004
VARYING RESISTOR SIZE REDUCES SYSTEM SWITCHING SURGES. J.H. Harlow, A.E. Kilgour. American Power Conference Proceedings, vol. 31, 1969, pp. 995-1003. The circuit breakers in the electrical system provide a means of controlling energy either through its protective operation, or as a switch for energizing or de-energizing a portion of the system. The EHV system and the contemplated UHV system demand that certain efforts be made to limit the voltage peaks so as to prevent unwanted flashovers during transient periods. System economics also indicate reduced costs in the insulation structure (BIL) of the system if the overvoltage peaks can be restrained to certain maximum values. The trend is for these values on the EHV and UHV systems to be determined by a statistical manner, i.e., from a probability curve. (Engineering Index abstract, from Compendex)

[1970] SW-006
CONTROLLING SWITCHING SURGES ON 1100-kV TRANSMISSION SYSTEMS. J.K. Dillard, J.M. Clayton, Jr., L.A. Kilar. IEEE Transactions, PAS, vol. 89, no. 8, Nov.-Dec. 1970, pp. 1752-1762. At 1100 kV, transient overvoltages caused by switching transmission lines pose the greatest stress to system insulation. These overvoltages must be limited to realistic values to make 1100 kV transmission economically attractive. Various alternatives for limiting switching surges including controlled and uncontrolled multi-step resistor breakers are investigated under many different system conditions. Several of these alternatives are found to be capable of limiting surge magnitudes to acceptable values. (IEE abstract, from Inspec)

[1970] SW-007
NEW GOALS FOR EHV AND FUTURE UHV POWER CIRCUIT BREAKERS. W.M. Leeds, R.E. Friedrich, T.E. Browne, Jr., C.L. Wagner. Westinghouse Engineering, vol. 30, no. 4, July 1970, pp. 120-124. High-voltage SF6 circuit breakers are now being built to meet the difficult requirements of EHV and UHV power systems. Modular breaker construction can be provided to limit switching transients within 2.0, 1.7, or 1.5 per unit of normal crest voltage. Performance can be further improved by the addition of shunt capacitance on the line side of the breaker. (IEE abstract, from Inspec)

[1970] SW-008
SWITCHING OVERVOLTAGES IN EHV AND UHV NETWORKS. G. Koppl, E. Ruoss. Brown Boveri Review, Dec. 1970, p. 554f. The article deals with the manifold switching operations and network parameters which affect the size and shape of switching overvoltages. Special attention is paid to means of limiting overvoltages occurring today and expected in the future. This is followed by a review of the main problems which require further investigation. (Abstract from article)

[1970] SW-REF
DIELECTRIC STRESSES (in Italian). G. Carrara, A. Clerici. Elettrotecnica, vol. 57, no. 10, Oct. 1970, pp. 581-593. For abstract, see entry [1970] IC-003.

[1971] SW-009
POWER CIRCUIT BREAKERS IN ULTRA-HIGH-VOLTAGE NETWORKS: TECHNICAL AND ECONOMICAL PROBLEMS AND SOLUTIONS (in German). P. Baltensperger. Elektrotechnische Zeitschrift, vol. 92, no. 12, 1971, pp. 690-694. Circuit breakers for voltages between 1000 and 1500 kV can be developed from existing designs for lower voltages by consistent extrapolation. The stresses imposed by short-circuit currents and transient recovery voltage are relatively harmless, whereas the problems of insulation and voltage stresses--especially those caused by switching surges--become very severe. Such operations as auto-reclosing and switching in the face of phase opposition at these very high voltages require particular examination and it may be that new practices will have to be introduced in the operation of networks. (IEE abstract, from Inspec)

[1971] SW-010
NEW SCOPE FOR EHV AND FUTURE UHV CIRCUIT BREAKERS. W.M. Leeds, R.E. Friedrich, T.E. Browne, C.L. Wagner. Polytechnisch Tijdschrift Elektrotechniek Elektronica (Netherlands), vol. 26, no. 11, May 26, 1971, pp. 417-422. Solving the problem of circuit overvoltages in EHV and UHV systems calls for a new approach in switch designs. The superiority of a SF6 high-voltage circuit breaker over compressed air makes it very suitable for the purpose in view. Westinghouse standard switches are available with over-voltage limitations not exceeding 1.0, 1.7 or 1.5 per unit of normal mains voltage. The performance can be raised further by addition of shunt capacity on the busbar or input voltage side. (IEE abstract, from Inspec)

[1971] SW-REF
CHARACTERISTICS OF HIGH POWER LABORATORY SUPPLIED BY A 735 kV NETWORK. A. Dupont, J. Aubin. IEEE Conference Record: International Symposium on High Power Testing, July 21-23, 1971, Portland, Oregon. For abstract, see entry [1971] TF-004.

[1972] SW-011
SWITCHGEAR FOR ULTRA-HIGH-VOLTAGES. Energy International, vol. 9, no. 3, March 1972, pp. 16-19. With 1200 and 1500 kV transmission systems proposed for the next decades, the choice of suitable switchgear becomes a more complex undertaking. Small-oil-volume, airblast and SF6 circuit breakers may eventually be displaced by vacuum interrupters. Investigations continue into breakers for UHV direct current circuits. (IEE abstract, from Inspec)

[1972] SW-012
1100 kV DISCONNECT SWITCH DESIGN, TESTS, AND APPLICATION AT THE WALTZ MILL 1100 kV STATION. C.J. Ahrano, J.P. McKinnon. IEEE Transactions, PAS, vol. 91, no. 4, July-Aug. 1972, pp. 1606-1613. The Waltz Mill project, performing accelerated life testing of prototype samples of 115 kV to 750 kV, is part of the Electric Research Council's underground transmission system research program. Waltz Mill also serves as a prototype of 1100 kV overhead type substations. This paper describes the design and testing of 1100 kV disconnect switches for application at Waltz Mill and on future systems. (Engineering Index abstract, from Compendex)

[1972] SW-014
SF6-INSULATED METALCLAD SWITCHGEAR FOR ULTRA-HIGH VOLTAGES. W. Boeck, H. Troger. CIGRE, Aug. 1972, paper 23-08. The heavy gas SF6 has been employed as an arc-extinguishing medium since 1959 and for the insulation of switchgear since 1965. This relatively new practice would appear to be successful even at the very high service voltage of 1300 kV. This is proved with the aid of drafts for SF6 insulated and conventional switchgear for 1300 kV. Excellent experience has been gained so far with approximately 320 bays in the voltage range up to 145 kV, and approximately 60 bays from 170 to 362. The problems with voltages of up to 500 kV can be mastered easily today, but considerable research and development are still necessary for the construction of metalclad switchgear for higher voltage. This paper is therefore limited to the treatment of problems whose solution, from today's point of view, may be considered as being particularly progressive. The question of overvoltages presents special difficulties with very high service voltages in conjunction with long transmission lines. This problem has therefore been dealt with in detail. (Abstract from article)

[1972] SW-016
PERFORMANCE OF CIRCUIT BREAKERS FOR UHV NETWORKS (in French). A. Dupont, V. Narancic. Canadian Communications & EHV Conference, Montreal, Nov. 9-10, 1972, IEEE publication no. 72 CHO 698-1-REG-7, p. 107. This paper gives the results of calculations made on a mathematical model for 750 kV. (Abstract from article)

[1972] SW-018
EHV BREAKER RATED FOR CONTROL OF CLOSING VOLTAGE SWITCHING SURGES TO 1.5 PER UNIT. R. Yeckley, R. Friedrich, M. Thuot. IEEE Transactions, PAS, vol. 91, no. 2, March-April 1972, pp. 399-403. A 550 kV circuit breaker has been developed which demonstrates the feasibility of meeting the anticipated stringent switching surge limitation of UHV transmission systems of 1100 kV and above. This improved circuit breaker with two-step resistor insertion and a times closing system limits switching surges to 1.5 per unit in 98 percent of the closing operations with a maximum of 1.65 per unit. The paper contains a description and the results of verification tests of the circuit breaker and the timed closing system which made meeting these requirements practical. (IEE abstract, from Inspec)

[1973] SW-020
CURRENT AND FORTHCOMING DEVELOPMENTS IN CBs. C.J.O. Garrard. Electronics Equipment (U.K.), vol. 12, no. 4, April 1973, p. 56 f. The paper deals with developments in vacuum interrupters and solid-state circuit breakers. Circuit breakers for HVDC and UHVAC transmission systems are also discussed. (IEE abstract, from Inspec)

[1973] SW-021
SWITCHING IMPULSE CHARACTERISTICS OF UHV STATION POST INSULATORS. A.R. Hileman, H.W. Askins. IEEE Transactions, PAS, vol. 91, no. 1, Jan.-Feb. 1973, pp. 139-144. Switching impulse tests were performed on single-column station post insulators having heights from 5 to 20 feet mounted atop grounded support structures having heights from 8 to 20 feet. Wavefronts of 120- and 1000-μs were used.

Results can be used to obtain preliminary estimates of requirements for EHV and UHV stations. (Abstract from article)

[1973] SW-022
THE AIR-BLAST CIRCUIT BREAKER. T. Kelsey, H.C. Petty. Philosophical. Transactions of the Royal Society of London, Mathematical and Physical Sciences (U.K.), vol. 275, no. 1248, 1973, pp. 131-138. The current design trends for today's HV airblast circuit breakers are described. The special advantages of using air as a switching medium are related to the requirements of the present and future needs of EHV and UHV supply networks. Some research currently being carried out throughout the world with relevance to gas-blast interrupters is mentioned. (IEE abstract, from Inspec)

[1973] SW-REF
REDUCTION OF FAULT CLEARING OVERVOLTAGES BY MEANS OF PRE-INSERTION RESISTORS IN CIRCUIT BREAKERS. A. Ametani. Science and Engineering Review (Japan), vol. 14, no. 3, Dec. 1973, pp. 129-140. For abstract, see entry [1973] IC-018.

[1974] SW-024
GENERAL REPORT OF GROUP 13. SWITCHING EQUIPMENT. E. Ruoss. Electra (France), no. 37, Dec. 1974, pp. 75-80. The following subjects are dealt with: transient switching voltage problems, e.g., total and initial shape of transient recovery voltage and switching overvoltages in HV, EHV and UHV systems; phenomena around zero and synthetic testing; and, reliability of circuit breakers. (IEE abstract, from Inspec)

[1974] SW-REF
PHASE-TO-GROUND AND PHASE-TO-PHASE SWITCHING-SURGE FLASHOVER OF EXTERNAL INSULATION OF UHV STATIONS. H.A. Rohlfs, L.E. Zaffanella. IEEE Transactions, PAS, vol. 93, no. 2, March-April 1974, pp. 518-528. For abstract, see entry [1974] IC-022.

[1975] SW-025
REQUIREMENTS FOR GAS-INSULATED EQUIPMENT THROUGH 1980. R.E. Friedrich. American Power Conference Proceedings, vol. 37, 1975, pp. 1128-1135. In the area of gas-insulated transmission equipment, which includes breakers, substations, and transmission lines, developments to 1980 and beyond can be projected fairly well from presently available apparatus ratings and design approaches being considered. In this paper, consideration includes voltage ratings from 115 kV to UHV levels where--except for certain oil breaker ratings--SF6 gas is the universally accepted insulation medium. (IEE abstract, from Inspec)

[1975] SW-026
THE PRESENT STATE AND FUTURE DEVELOPMENTS IN THE MANUFACTURE OF HIGH-VOLTAGE CIRCUIT BREAKERS (in Russian). V.K. Matvienko, I.M. Bortnik, A.M. Bronshtein. Elektrotekhnika (USSR), no. 6, June 1975, pp. 1-6. The article examines the principal lines of development within the Soviet Union of the basic types of circuit breaker--bulk oil, minimum oil, airblast, vacuum interrupters and SF6--at all transmission voltages up to 1150 kV. (IEE abstract, from Inspec)

[1975] SW-027
ELECTROMECHANICAL CHARACTERISTICS OF AIR-BLAST 750 kV CIRCUIT BREAKERS OF SERIES VVB. V.S. Rashkes, K.V. Khoetsian, Yu. I. Vishnevskii. Elektrichestvo (USSR), no. 4, pp. 41-45, selected articles translated in Electric Technology USSR (U.K.), no. 2, 1975, pp. 19-30. Synchronous closure is studied as a means of surge limitation in UHV systems (at 750 kV or more). The technique is able to suppress the transient component of overvoltages in closure and automatic reclosure of transformers and lines. Soviet 750 kV breakers are found to be applicable in this respect from a design study. (IEE abstract, from Inspec)

[1975] SW-028
MAJOR PRINCIPLES IN SWITCHING OVERVOLTAGE PROTECTION OF EHV POWER TRANSMISSIONS. A.D. Vinogradova, Yu.I. Lyskov. Proceedings of the Symposium on EHV AC Power Transmission, US-USSR committee, Feb. 17-27, 1975, Washington, D.C., published by Bonneville Power Administration, pp. 77-100. Small wave impedance and relatively low ratio of short circuit capacity to natural capacity of lines for the systems adjoining power transmisions, great length of the sections between substations, and small capacity of compensatory coils of the autotransformers--all this leads to high overvoltages and the high probability of the appearance of their limiting values in fixed as well as in transitional processes with switching in 750 to 1150 kV transmission as compared to 500 kV. The usually used 2.5 ratio as for 500 kV would lead to significant increases in cost of lines, open distribution devices, and apparatus. Lowering the permissible ratio by 0.1 might lower cost of line for EHV by 0.5 to one percent and of substations--excluding the cost of overvoltage limitation facilities--by 1.5 to 2.5 percent. The paper explores the possibilities. (Abstract from article)

[1975] SW-REF
SWITCHING SURGE FLASHOVER CHARACTERISTICS OF LONG SPHERE-PLANE GAPS FOR UHV STATION DESIGN. H.M. Schneider, F.J. Turner. IEEE Transactions, PAS, vol. 94, no. 2, March-April 1975, pp. 551-560. For abstract, see entry [1975] STA-005.

[1976] SW-029
SUBSTATION EQUIPMENT: PROJECTED NEEDS FOR THE NEXT VOLTAGE STEP. R. Flugum. IEEE Region Six (Western USA) Conference on Energy for the Future, Tucson, Arizona, April 7-9, 1976. Another step in transmission voltage above 800 kV appears necessary if fuel substitution and large concentration of generation continues. Also evident, from 1200 kV test stations under construction, is that substations for these voltages will be gas insulated because of size and height considerations. Although many lower voltage gas substations are in service, most of the equipment in these stations are similar to equipment used in outdoor air-insulated installations and, as such are not optimized for use in a gas environment. Design changes, most of them departures from conventional practices, are necessary. This approach will result in maximizing the environmental advantages possible, thus the transition from air to gas will be complete and involve the entire station. (IEE abstract, from Inspec)

[1976] SW-030
NEW TWO-STAGE SYNTHETIC CIRCUIT FOR TESTING EXTRA-HIGH AND ULTRA-HIGH CIRCUIT BREAKERS. H. Moravova. Electrotechniki Obzor (Czechoslovakia), vol. 65, no. 6, June 1976, pp. 332-336. The article presents a survey of the principles of new synthetic test circuits for solving the problems of tests of UHV and EHV circuit breakers at low frequencies of the restriking voltage. Connection and function of the original two-stage circuit are described in detail and the calculation of the energy of the capacitors is given. The operating reliability of the new circuit is experimentally verified under actual test conditions. (IEE abstract, from Inspec)

[1976] SW-REF
MODERN DEVELOPMENTS IN LARGE DISTRIBUTION TRANSFORMERS AND TAP CHANGERS (in German). K. Gadek. Verband Deutscher Elecktrotechniker (VDE) Fachberichte, vol. 29, 1976, pp. 61-74. For abstract, see entry [1976] PT-024.

[1977] SW-031
NEW LEVELS OF PERFORMANCE FOR UHV OUTDOOR-TYPE CIRCUIT BREAKERS REQUIRED FOR POWER TRANSMISSION SYSTEM. International Conference on the Design and Application of EHV Substations, Nov. 22-24, 1977. IEE special publication no. 57, p. 140 f. (Abstract unavailable)

[1977] SW-032
LYONS 1100/1200 kV GIS TEST PROGRAM, QUARTERLY REPORT NO. 3, APRIL 1, 1977 - JUNE 30, 1977. P.L. White. 1100/1200 kV Prototype Transmission Line Project, Bonneville Power Administration, Portland, Oregon. This review of ERDA, EPRI, and other reports includes updates on (1) intended 1978 installation at Waltz Mill of GITL to serve in part as interface to other GIS equipment; and (2) ERDA contract with General Electric for 1200 kV GIS instrument transformers with relation to development of site and station service supply at BPA's Lyons test site. (Abstract from report)

[1977] SW-033
ON THE ACCURACY OF GENERALIZED STATISTICAL CHARACTERISTICS OF OVERVOLTAGES PRODUCED BY CLOSING AND RECLOSING OF TRANSMISSION LINES. N.N. Beljakov, K.I. Kuzmicheva, V.S. Rashkes, J. Jirku. Acta Technica Ceskoslovensk Akademie Ved (USSR), vol. 22, no. 5, 1977, pp. 511-519. The article deals with the problems of using the generalized statistical characteristics of overvoltages produced by closing long UHV and EHV transmission lines. Assuming the invariability of the relative overvoltage factor on the line end, the authors investigate the influence of the type and of the state of the circuit breaker on the moment of closing and thus on the magnitude of overvoltages. The investigation is based on numerous field measurements. It has been revealed that the effects of the electromechanical characteristics of circuit breakers, as well as the changes of the feeding network scheme, which influence the shape, the attenuation and the magnitude of the relative overvoltage factor result in errors ranging from 15 to 20 percent, assuming the utilization of mean experimental characteristics of the relative overvoltage factor for determining the overvoltage of any transmission line. (Engineering Index abstract, from Compendex)

[1977] SW-034
OUTDOOR AIRBLAST CIRCUIT BREAKERS (TYPE DLF) FOR UP TO 1100 kV, FOR EXTREMELY HIGH BREAKING CAPACITY AND MEETING SPECIAL REQUIREMENTS. E. Bross, H. Schubert, T.T. Tan. Brown Boveri Review, vol. 64, no. 5, May 1977, pp. 277-284. A project for extending the operating range of outdoor airblast circuit breakers (type DLF) at rated voltages up to 1100 kV is considered. A higher breaking capacity for the extinction chambers makes it possible to reduce the number of elements connected in series. Solutions to meet special requirements are described. The DLF range of circuit breakers has undergone continuous improvement; reliability tests indicate an extremely low failure rate. (Engineering Index abstract, from Compendex)

[1977] SW-035
APPLICATION AND OPERATION OF 500 kV GAS INSULATED SWITCHGEARS. S. Matsumura. Proceedings, IEE conference: The Design and Application of EHV Substations, Nov. 1977, London, England, pp. 96-100. This paper describes a 550 kV full GIS installed as an EHV switching equipment in the Ohi Nuclear Power Station of the Kepco, together with several points which were considered before deciding the adoption of this equipment and comments briefly on future prospect of GIS for UHV substations. (IEE abstract, from Inspec)

[1977] SW-036
NEW LEVELS OF PERFORMANCE FOR ULTRA-HIGH VOLTAGE OUTDOOR-TYPE CIRCUIT BREAKERS REQUIRED FOR POWER TRANSMISSION SYSTEMS. E. Thuries. IEE Conference Publication no. 157, 1977, pp. 140-145. Because of the simplicity of its construction, the SF6 breaker has made a place for itself up to 420 kV. Beyond that, in the UHV range, the airblast breaker retains practically a monopoly. This is a provisional situation since, depending upon the case, SF6 applications can be envisaged. The paper compares the qualities of SF6 and airblast breakers for UHV applications. In all probability the airblast breaker will continue to be the best solution for different situations calling for the no-load switching of lines or for high-speed interruption. Whatever the voltage levels adopted, the electrical equipment and particularly the circuit breakers will present no obstacle to the development of power transmission system. (Engineering Index abstract, from Compendex)

[1977] SW-REF
ELECTRICITE DE FRANCE AND THEIR EXTRA HIGH TENSION LABORATORY (in Spanish). G. Leroy. Rev. Electrotec., no. 243, 1977, pp. 48-52. For abstract, see entry [1977] TF-008.

[1977] SW-REF
A PROGRAM FOR UHV TRANSMISSION. H.N. Scherer, Jr., B.J. Ware, H.B. Thoren. American Power Conference Proceedings, vol. 39, 1977, pp. 1113-1120. For abstract, see entry [1977] SA-007.

[1978] SW-037
BEHAVIOR OF EHV AND UHV CIRCUIT BREAKERS EQUIPPED WITH RESISTORS DURING THE MAKING OPERATIONS. M. Cazzani, M. Lissandrin, S. Manganaro, G. Mazza. CIGRE, Aug. 1978, paper 13-10. The pre-arcing characteristics of the main auxiliary chambers of a UHV circuit breaker prototype equipped with closing resistors are determined taking into account the actual conditions during operational life. The impact of considering these characteristics in the evaluation of the thermal stresses on the resistors during the making operations on short-circuit and phase opposition is considered. The paper then examines the influence of these characteristics as well as the modeling of the circuit breakers in TNA studies with respect to the distribution of closing and reclosing overvoltages. (Abstract from article)

[1978] SW-038
THE APPLICATION OF SF6 IN SWITCHGEAR AND CIRCUIT BREAKERS (in German). A. Eidinger. Bulletin de l'Association Suisse des Electriciens, vol. 69, no. 22, November 18, 1978, pp. 1202-1206. The article includes: (1) an account of the properties of SF6 as dielectric and interrupting medium; (2) a summary of the present position of SF6 switch and circuit breaker design (especially of high-capacity single-pressure circuit breakers); (3) a review of totally-enclosed SF6-insulated switchgear for voltages up to 1000 kV; and (4) an account of the physiological and other effects in the atmosphere of SF6 and of the products of arcing in SF6, and the precautions that must be taken. (IEE abstract, from Inspec)

[1978] SW-039
1200 kV SF6 DISCONNECT/ISOLATOR SWITCH: FEASIBILITY STUDY. R.D. Garzon, F.M. Strenk. U.S. Dept. of Energy, contract no. ET-78C-01-3178. (Abstract unavailable)

[1978] SW-040
FUNDAMENTAL TECHNIQUES FOR GAS-INSULATED APPARATUS. Y. Murakami, S. Menju. Toshiba Review, no. 117, Sept.-Oct. 1978, pp. 5-12. The paper investigates various important factors affecting SF6 insulation characteristics and establishes pertinent criteria for design, product quality and maintenance. Gas-insulated apparatus is able to continue safe operation as long as SF6 density is kept within a permissible range. Therefore, gas leakage must be kept at a minimum. For this reason, improving gas sealing techniques constitutes a basic task. This paper presents various examples of fundamental techniques and their application to future HVDC and UHV apparatus. (Engineering Index abstract, from Compendex)

[1978] SW-041
ELECTRIC STRENGTH OF SUPPORT INSULATION OF UHV 330-1150 kV CIRCUIT BREAKERS. L.S. Slutskin. Electric Technology USSR (U.K.), no. 4, 1978, pp. 23-33. Tests on mast-type supports of 1400 mm insulators are reported. Present switching surge test methods by 500 and 5000 microsec. impulses indicate test voltages. It is necessary to compare insulation characteristics under different influences in UHV service. Special attention is given to screens and the position of stays. A supplier factor of safety is defined. (Engineering Index abstract, from Compendex)

[1978] SW-REF
UHV DISCONNECTORS: SWITCHING SURGE DESIGN AND TESTING OF EXTERNAL INSULATION. G. Carrara, A. Pigini, M. Polo-Dimel. IEEE Transactions, PAS, vol. 97, no. 6, Nov.-Dec. 1978, pp. 2094-2103. For abstract, see entry [1978] IC-039.

[1978] SW-REF
EVALUATION OF THE RISK OF FAILURE DUE TO SWITCHING SURGES IN UHV NETWORKS. G. Borgonovo, G. Santagostino, G. Cambelli, L. Lagostena, A. Porrino. CIGRE, 1978, paper 33-14. For abstract, see entry [1978] IC-038.

[1978] SW-REF
REDUCING THE SWITCHING TIMES DUE TO SHORT-CIRCUIT CURRENTS USING DISTANCE PROTECTION IN EHV/UHV TRANSFORMERS (in Czech). K. Kral. Energetika, vol. 28, no. 6, June 1978, pp. 247-251. For abstract, see entry [1978] PT-033.

[1979] SW-042
CIRCUIT BREAKER DEVELOPMENT PROGRAM FOR 1200 kV GIS. H.E. Spindle. IEEE conference publication no. 79 CH 1399-5-PWR, pp. 227-229. This paper describes the structure and organization of a project to develop a 1200 kV circuit breaker for gas-insulated substations. The primary function of this paper is to teach others the methods for planning complex programs to meet specific requirements. (Engineering Index abstract, from Compendex)

[1980] SW-043
CONSTRUCTIONS OF UHV SWITCHGEAR ON THE BASIS OF EXPERIENCES GAINED WITH EHV METALCLAD AND HYBRID SUBSTATIONS. A. Hazman, V. Phillippovich, W. Stolarz. CIGRE, 1980, paper 23-12. The authors describe the possible variants of metalclad and hybrid switchgear. These units are compared to the conventional air-insulated switchgear (at 420-525 kV). The problems of arrangement, the required area and space, the guiding principles of economy, and the aspects concerning service, operation, and maintenance are discussed as well. The paper deals with the experience gained through the erection and operation--up to now--of the 420 kV outdoor metalclad equipment. In this context, the frame structure required for the arrangement, and the measurements involved in the commissioning are treated. The applicability of the solutions is studied on the basis of stations being at present in the stage of design, construction, or beginning operations. Papers and examples are given concerning the possible variants of 800 kV substations. (Abstract from article)

[1980] SW-044
DESIGN AND APPLICATION OF BREAKERS BASED ON LATEST DEVELOPMENTS. A. Leibolt, A. Eidinger. IEEE publication no. 79 CH1399-5-PWR (SUP), 1980, pp. 355-360. Progress achieved in past years and limitations of existing interrupting principles are reviewed. Economic considerations prevent the use of a uniform technique for the broad spectrum of different requirements. In the future, air blast circuit breakers will be more economical for the UHV range and for extra-high interrupting currents whereas SF6 single-pressure interrupters are better suited for the lower voltage range up to 420 kV and interrupting currents up to 50 to 63 kA. Possible switchyard arrangements--conventional installations with live-tank breakers, hybrid solutions with partial SF6 insulation and GIS--are compared. (Engineering Index abstract, from Compendex)

[1980] SW-045
DEVELOPMENT OF A 1200 kV CIRCUIT BREAKER FOR GAS-INSULATED SUBSTATIONS. H.E. Spindle, C.L. Wagner, T.F. Garrity. American Power Conference Proceedings, vol. 42, 1980, pp. 687-691. In support of the continued growth of electric power transmission, the U.S. Department of Energy initiated a multidisciplinary R&D program for the next higher system voltage level. This paper describes a development project funded by the Department of Energy to provide the circuit breaker for this proposed new transmission system. See also CIGRE, Aug. 1980, paper 13-07. (Engineering Index abstract, from Compendex)

[1980] SW-REF
FIRST 765 kV SF6 STATION PROVES SUCCESSFUL. R. Matulic, L.M. Laskowski. Electrical World, vol. 194, no. 3, Aug. 1, 1980, pp. 44-47. For abstract, see entry [1980] STA-016.

[1980] SW-REF
1200 IV SUBSTATION TASK FORCE QUARTERLY REPORT, JANUARY 1, 1980-MARCH 31, 1980. G.W. VanGinhoven. Bonneville Power Administration. For abstract, see entry [1980] IC-051.

[1981] SW-046
AC POWER CIRCUIT BREAKER FOR 800 kV AND ABOVE: REQUIREMENTS, SPECIFICATIONS AND CRITERIA FOR THE EVALUATION ON THE DIFFERENT DESIGNS. All-India EHV Forum, Bombay, India, Dec. 3-5, 1981. (Abstract unavailable)

[1981] SW-047
DEVELOPMENTS IN THE WEST GERMAN ELECTRICITY SUPPLY UNDERTAKINGS (in Dutch). H.H. Schramm. Polytechnisch Tijdschrift Elektrotechniek Elektronika, vol. 36, no. 1, Jan. 1981, pp. 19-29. Distribution networks (1980 figures) in West Germany accommodate a peak load of 70,000 MW and 300,000 GWh. Simplified maps show the transmission line routes in the main land area linking 380/110 kV and 110/30 kV or 110/10 kV transformer stations. West Berlin has an isolated distribution system, also 380/110/10 kV. Other voltage systems involve 420 kV, 245 kV and 123 kV lines; projects for year 2000 onwards are planned for 800 kV and 1050 kV. Switching short circuit current flows are discussed in terms of the dc constituents and some statistical data is given as faults per 100 km line length for one-, two- or three-phase defects. Behavior patterns for SF6 quenched switchgear are outlined in relation to voltage/current and voltage/time characteristics. An illustration and description is included for a medium voltage vacuum switch rated at 40 kA, 36 kV. (IEE abstract, from Inspec)

[1981] SW-REF
VERY-HIGH-VOLTAGE TRANSFORMER AND EQUIPMENT SPECIFICATIONS (in Russian). M.N. Khodzhaev. Izvestiya Visshykh Uchebnykh Zavedenii, Elektromekhanika, no. 11, Nov. 1981, pp. 1185-1158. For abstract, see entry [1981] PT-046.

[1981] SW-REF
INVESTIGATION OF PARTIAL DISCHARGES GENERATED BY SWITCHING OVERVOLTAGES IN INSULATION OF EXCITED WINDINGS IN UHV TRANSFORMERS (in Polish). J. Galczak. Rozprawy Elektrotechniczne, vol. 27, no. 1, 1981, pp. 165-178. For abstract, see entry [1981] PT-045.

[1981] SW-048
ALL-UNION TECHNOLOGY CONFERENCE: USE OF LARGE BETEL RESISTORS AND RESISTOR IMPLANTS IN POWER ENGINEERING. B.I. Kobalev, R.V. Manchuk. Elektrichestvo (USSR), no. 7, pp. 76-77, translated in Electric Technology USSR (U.K.), no. 3, 1981, pp. 63-68. Betel is a portmanteau word describing so-called electrotechnical cement resistors as a low-cost substitute for metallic resistors. Regarded as a composite material in the nature of a world advance, research into its applications needs coordination. Over the last 10 years about 40 betel resistor implants have been used successfully to dampen electromagnetic and electromechanical transients and to limit overvoltages and short circuit currents, e.g., as shunt resistors for 110-330 kV circuit breakers. Various possible applications are reported including 1150 kV breakers. Work on the resistors is to continue under the 11th five-year plan. (Engineering Index abstract, from Compendex)

[1982] SW-049
1200 kV SYSTEM STUDY. Brown Boveri Electric, Inc., Chalfont, Pennsylvania. Report no. DOE/ET/29064-1, Feb. 1982, contract no. AC01-78ET29064. The 1200 kV systems study project consisted of two major tasks: definition of performance requirements for a 1200 kV circuit breaker for use in as gas-insulated substation; and performance analysis of a 1200 kV insulator/disconnect switch for gas-insulated substation. For the first task, the performance requirements included: insulation requirements--60 Hz, switching surge and lightning, both phase-to-ground and across the open breaker; prospective transient recovery voltage requirements related to fault current interrupting; an opening scheme capable of limiting phase-to-ground and across the breaker overvoltages resulting from line dropping and out of phase switching; a closing scheme capable of limiting line overvoltages during reclosing to 1.5 per unit (2 percent level). The investigation of each of these items and of lightning characteristics and effects is discussed. The 1200 kV disconnect switch study analyzed bus energizing, bus de-energizing, transformer de-energizing, and the effect of hysteresis losses. Results from these analyses are presented. (NTIS abstract)

[1982] SW-050
GIS AND ALTERNATE SYSTEMS FOR UHV SUBSTATIONS. B.J. Ware, A. Nourai, R.L. Perlas, L.A. Swenson, L. Morales. Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 301-313. Available from Bonneville Power Administration. This is a summary of efforts of the American Electric Power Service Corporation (AEP) and BPA in UHV studies and development of 1600 kV and 1200 kV respectively. Cost comparisons are made for air-insulated and gas-insulated designs. High-side switching, line compensating, shunt reactor schemes, and use of metal oxide arresters are also common requirements of 1600 kV and 1200 kV but other distinct differences exist in design concepts. (Abstract from article)

[1982] SW-051
FAULT-DETECTION SENSORS FOR GAS-INSULATED EQUIPMENT, FINAL REPORT. J.K. Wittle, J.M. Houston, G.J. Carlson, W.D. Davis, A.M. Itan. EPRI report EL-2249, Feb. 19, 1982. The EPRI-GE program develops new techniques for detecting and locating faults for internal insulation degradation in SF6-insulated equipment, particularly coaxial conductors used extensively in EHV and UHV substations. The development is described of three types of sensors useful in determining the location of high current faults within the enclosed apparatus: resistive thin-film optical, and magnetic. All are small in size, operate from inexpensive batteries, are long-lived, and incorporate inherent memory. Each has at least one visual output indicator which is activated when a fault current of sufficient magnitude has occurred. The thin-film sensor changes resistance from approximately 10^{12} to 10^{6} ohms when exposed to typical arced SF6 by-products. The optical sensor detects arc light using a phototransistor coupled to an optical fiber which penetrates the container. The resistive and optical sensors may be able to detect prolonged low-level arcing (corona) even without a high-current fault and thus could be valuable in providing advance warning of incipient faults. The resistive and optical sensors that require conductor penetrations and therefore retrofitting to existing GIS equipment may be inconvenient. The magnetic sensor has the advantage that no penetration is required and retrofitting is simple. (NTIS abstract)

1982] SW-052
STUDY ON OPTIMAL CONFIGURATION OF EHV AND UHV LARGE-CAPACITY GAS-INSULATED SUBSTATION EQUIPMENT. N. Nimura, S. Kakano, K. Oishi, M. Tamura. American Power Conference Proceedings, vol. 44, 1982, pp. 780-785. The paper presents the results of the technological development of EHV gas-insulated substation equipment particularly with regard to its economic aspects, taking the typical 275 to 800 kV 6000 to 12000 A GIS with outdoor, double bus, air-insulated inlet arrangement, which is widely used in Japan, as an example. (IEE abstract, from Inspec)

[1982] SW-053
FAST TRANSIENT OVERVOLTAGES IN GIS CAUSED BY THE OPERATION OF ISOLATORS. T. Yoshizumi, S. Matsuda, T. Nitta. Proceedings, 3rd International Symposium on Gaseous Dielectrics, Knoxville, Tennessee, March 7-11, 1982, pp. 456-465. Published by Pergamom Press, New York. Editor: L.G. Christophorou. Operations of an isolator in GIS generate fast transient overvoltages due to the reflections of potential front in the system. The overvoltages may be hazardous for the insulation of GIS particularly for high voltage systems where reduced LIWL is applied. The fast transient overvoltages are measured on a prototype UHV isolator with gas-insulated bus of about 10 meters in length. The results of the measurement are compared with computer analysis using electromagnetic transient program (EMTP). Modeling of GIS and the factors to be influential in the phenomena are studied in the analysis. The impact of the fast transient on the insulation coordination of GIS is also discussed. (IEE abstract, from Inspec)

[1982] SW-054
DIELECTRIC STRENGTH OF SF6 IN DIVERGENT FIELD CONFIGURATION. A.F. Rohlfs, W.N. Kennedy. Proceedings, 3rd International Symposium on Gaseous Dielectrics, Knoxville, March 7-11, 1982. Published by Pergamon Press, N.Y. Editor: L.G. Christophorou. The work presents the results of an investigation to determine the critical breakdown and withstand gradients of SF6 at 45 psig in divergent fields with enhancement factors in the range of =1 to 6. Voltages up to 500 kV rms sixty-hertz, 1000 kV switching impulse, and 1100 kV lightning impulse were investigated. Rounded edge disks mounted perpendicular to a ground plane were used to produce the desired fields. Edge radii were 0.25, 0.5, and 2.5 inches. Tests were made with both bare disks and disks coated with 15 mils of epoxy. The experiments were all performed above the critical pressure for the geometry used, and direct breakdown stresses agree closely with published data using smaller radii. (IEE abstract, from Inspec)

[1983] SW-055
CONTRIBUTION TO 1000 kV GAS-INSULATED SWITCHGEAR. P. Leupp. Proceedings, CESI Symposium, 1983. Based on the report's facts as well as on the general advantages of GIS (such as higher reliability, compact design insensitivity to pollution, etc.), the author believes that switchgear with voltages higher than 800 kV will be only of the GIS type. (Abstract from article)

[1983] SW-056
1000 kV GAS-INSULATED SWITCHGEAR (SUBSTATION SWITCHGEAR). G. Mazza, B. Mazzoleni. Energia Electrica (Italy), vol. 60, no. 12, Dec. 1983, pp. 486-95. The paper summarizes research results of the 1000 kV project with the aim of defining the design and construction characteristics of the UHV substation components. The article describes the research done on switchgear development and the use of SF6 circuit breakers, transformers, disconnectors and surge arrestors. (IEE abstract, from Inspec)

[1984] SW-057
AC POWER CIRCUIT BREAKER FOR 800 kV AND ABOVE: REQUIREMENTS SPECIFICATION AND CRITERIA FOR THE EVALUATION OF THE DIFFERENT DESIGNS. G. Aldrovandi, G. Borgonovo, G. Rovelli, S. Santagostino. Energia Electrica (Italy), vol. 61, no. 3, March 1984, pp. 106-15. For the selection of 800 kV and above circuit breakers. The design criteria, the electrical performance, the electrical and mechanical reliability and the problem of maintenance have been analysed. The above concepts have been applied to the evaluation of the various 800 kV and above circuit breakers types at present available. Some of the trends on the design of UHV circuit breakers are examined. The criteria which have been adopted for the preparation of the specficiaton and for the testing procedures are presented. (IEE abstract, from Inspec)

[1984] SW-058
A KINEMATIC TRANSDUCER FOR LABORATORY TESTING OF POWER CIRCUIT BREAKERS UP TO 100 kA and 1000 kV. A. Brandolini, E. Carminati, S. Rovelli. Energie Elettrica (Italy), vol. 61, no. 1, Jan. 1984, pp. 37-46. The paper describes the development of apparatus suitable for the measurement of the relative displacements between the contracts of high voltage circuit breakers. Firstly, the required transducer characteristics are given and solutions for the transduction and the transmission of the measured quantity are described and discussed. Lastly, the construction and the tests carried out to check the behavior of the various elements of the transducer are described. (IEE abstract, from Inspec)

[1984] SW-059
LIMITATION OF OVERVOLTAGES DURING SWITCHING OF LARGE CAPACITOR BANKS IN UHV SYSTEMS (in Russian). T.M. Lazimov. Izvestiya Vysshyich Uchebnykh Zavedenii, Energetika (USSR), no. 9, Sept. 1984, pp. 56-59. A mathematical model is employed for investigating the effectiveness of various measures to limit overvoltages during

switching of capacitor banks in ultra high voltage (UHV) power supply systems. The results show that these overvoltages can be limited effectively by employing synchronized connection and double-action breakers with resistors in parallel. Control of the conduction cycle of static compensators reduces the rate of the switching overvoltages a little, and may be used as an additional measure. Phase connections of the capacitor bank with a resistor. Introduced during the switching period into neutral, can also produce a relatively effective switching action. (IEE abstract, from Inspec)

[1984] SW-060
A METHOD OF DETERMINING THE ERROR OF CASCADE CURRENT TRANSFORMERS DESIGNED FOR OPERATION UNDER TRANSIENT CONDITIONS (in Russian). N.A. Stognii, B.S. Tankevich, E.N. Chernenko, V.A. Bogdanevich. Tekhika Elektrodinamiki, no. 2, March-April 1984, pp. 92-97. A method of determining the overall errors of a cascade-type current transformer in transient conditions is described. Oscillograms are presented, showing the results of computer calculation of the overall errors in an 1150 kV cascade current transformer under transient operating conditions. (IEE abstract, from Inspec)

[1984] SW-REF
METAL-ENCLOSED 1000 kV TESTING STATION FOR ROUTINE TESTING OF SF6-INSULATED SWITCHGEAR. L. Fischer, L. Hashoff, G. Luxa. Siemens Power Engineering, vol. 6, no. 4, July-Aug. 1984, pp. 204-208. For abstract, see entry [1984] TF-018.

[1985] SW-061
ANALYSIS OF A 1200 kV CIRCUIT BREAKER FOR A GAS INSULATED SUBSTATION, FINAL REPORT. H.E. Spindle, Project Manager. U.S. Department of Energy, contract no. DE-AC01-79ET-29067. Publication no. DOE/ET/29067-T2 (DE85011873) available from NTIS. This report describes the work carried out under DOE contract to analyze and design a circuit breaker for use in 1200 kV gas insulated substations. The first part of the project was devoted to a thorough analysis of the requirements for the circuit breaker from the standpoint of the electrical system in which it would operate. Based on these operating requirements a conceptual design was selected and all of the components of the circuit breaker were designed, modeled and verified. Finally a plan was prepared for the construction of a complete circuit breaker. (Abstract from report)

SHUNT REACTORS -SR-

[1969] SR-001
SHUNT REACTOR COMPENSATION ON PRESENT AND FUTURE TRANSMISSION SYSTEMS. J.M. Feldman, D.D. Wilson. American Power Conference Proceedings, vol. 31, April 22-24, 1969, pp. 842-853. Shunt reactor technology, including design, testing and application, is of primary importance to the operation of an investment in EHV and UHV transmission systems. Approximately 30 utility companies in the United States now use, or plan to install, shunt reactor compensation. The transmission voltage levels employing compensation cover the spectrum from 115 kV through 765 kV with the majority of the approximately 15,000,000 kVAR of installed or planned reactors applied on 345 kV and 500 kV systems. (Engineering Index abstract, from Compendex)

[1969] SR-REF
ANACOM STUDIES FOR AN 1100 kV TRANSMISSION SYSTEM. J.K. Dillard, J.M. Clayton, L.A. Kilar. American Power Conference Proceedings, vol. 31, 1969, pp. 834-841. For abstract, see entry [1969] IC-002.

[1971] SR-REF
REDUCTION OF SWITCHING OVERVOLTAGES IN EHV AND UHV SYSTEMS. H.B. Thoren. IEEE Transactions, PAS, vol. 90, no. 3, May-June 1971, pp. 1321-1326. For abstract, see entry [1971] IC-009.

[1971] SR-REF
ASEA PRESENT THE WORLD'S FIRST UHV POWER TRANSFORMER. P. Hessen. ASEA Journal (Sweden), vol. 44, no. 5, 1971, pp. 120-122. For abstract, see entry [1971] PT-006.

[1971] SR-REF
ASEA DEVELOPMENTS IN THE UHV FIELD. B. Thoren. ASEA Journal (Sweden), vol. 44, no. 5, 1971, pp. 109-117. For abstract, see entry [1971] PT-008.

[1972] SR-002
APPLICATION TO EHV TRANSMISSION OF STATIC COMPENSATION USING SATURATED REACTORS. R. Banks, E. Friedlander, A. Gavrilovic. Canadian Communications & EHV Conference, Montreal, Nov. 9-10, 1972, IEEE publication no. 72 CHO 698-1-REG-7, pp. 153-154. The practice of raising the power limit--related to phase angle between sending and receiving e.m.f.'s--by series capacitor compensation is well known. The advantages of shunt compensation using saturated reactors are less well known. In this method, the line is subdivided into shorter sections at the junctions of which the reactive power balance is automatically controlled by shunt voltage stabilizers. This system has a stability limit no longer set by phase angles but by the total shunt capacitive MVAr available. Treble-Tripler reactors possess the straight saturation characteristics required for accurate voltage stabilization. Furthermore, they generate negligible harmonics and store very little magnetic and no kinetic energy, which explains their fast response. (Abstract from article)

[1973] SR-003
NEW SHUNT REACTOR PRINCIPLE PROVED: DESIGNED DATA AND FACTORY TEST RESULTS FOR UNITS BUILT ON THE INSULATED CORE PRINCIPLE. J.P. Vora, B.L. Johnson, H.C. Barnes. IEEE Transactions, PAS, vol. 92, no. 3, May-June 1973, pp. 900-906. This paper describes the first application of the insulated core principle for management of fields of a 765 kV shunt reactor installed on the AEP system. Design techniques and test data are presented and the modular concept of reactor construction in an oil-filled device is described. Results of feasibility studies of reactors for future UHV systems are included. (Engineering Index abstract, from Compendex)

[1975] SR-004
COMPENSATION OF LONG DISTANCE AC TRANSMISSION LINES BY SHUNT CONNECTED REACTANCE CONTROLLERS. D.A. Woodford, M.Z. Tarnawecky. IEEE Transactions, PAS, vol. 94, no. 2, March-April 1975, pp. 655-664. A proposal is presented for compensation of long ac transmission lines entirely by shunt devices designated as reactance controllers. Fundamental design of the reactance controller as a transmission line shunt compensating device is established. Application of reactance controllers to transmission lines is described as well as a theoretical approach for the transmission planner to evaluate controlled shunt reactance compensation for future and existing transmission schemes. (Engineering Index abstract, from Compendex)

[1978] SR-005
ADVANCED CONCEPTS FOR A 1200 kV SHUNT REACTOR. First Quarterly Progress Report, Sept. 28, 1978-Dec. 31, 1978, Westinghouse Electric Corp., Muncie, Indiana, contract no. ET-78-C-01-3077. The objective of this program is to explore new concepts for inductive shunt reactor designs for integration into a 1200 kV gas-insulated substation. The most promising design must exhibit low dimensional profile with reduced weight, lower losses, lower noise level and smaller amplitude of vibration when compared with the units of equivalent rating built with the present day technology. The planning and organization of this research program are described. (NTIS abstract)

[1978] SR-REF
EVALUATION OF THE RISK OF FAILURE DUE TO SWITCHING SURGES IN UHV NETWORKS. G. Borgonovo, G. Santagostino, G. Gambelli, L. Lagostena, A. Porrino. CIGRE, 1978, paper 33-14. For abstract, see entry [1978] IC-038.

[1978] SR-REF
OPERATING CONDITIONS OF SWITCHING SURGE ARRESTERS IN CONNECTING SHUNT REACTORS ACROSS SPARKGAPS (in Russian). M.L. Levinshtein, Yu. I. Kyskov, G.V. Chernova. Elektrichestvo, no. 8, Aug. 1978, pp. 5-11. For abstract, see entry [1978] SA-011.

[1978] SR-REF
LYONS 1100/1200 kV SUBSTATION TASK FORCE QUARTERLY REPORT, JULY 1, 1978-SEPTEMBER 30, 1978. K.M. Watkins. 1200 kV Prototype Transmission Line Project. Bonneville Power Administration, Portland, Oregon. For abstract, see entry [1978] SA-014.

[1981] SR-006
ADVANCED CONCEPTS FOR A 1200 kV SHUNT REACTOR. VOL. 1: EXPLORATION OF NEW CONCEPTS FOR INDUCTIVE SHUNT REACTOR DESIGNS FOR INTEGRATION INTO A 1200 kV GAS-INSULATED SUBSTATION. Final report, DOE/ET/29073-T1, March 27, 1981. Available from NTIS. The objective of this program is to explore new concepts for inductive shunt reactor designs for integreation into a 1200 kV gas-insulated substation. The most promising design should exhibit low dimensional profile with reduced weight, lower losses, and lower noise level when compared with units of equivalent rating designed with present day technology. To meet the objectives, several advanced concepts of shunt reactor design were studied. The major concepts explored in this project included: sulfur hexafluoride gas-insulated, foil type windings, high reluctance core materials, and heat transfer via the gaseous medium. As a result of the study, a shunt reactor was designed through an application of the advanced concepts with the conclusion that the program objectives could be attained. (NTIS abstract)

[1982] SR-008
UHV SHUNT REACTORS: TECHNICAL PROBLEMS AND TEST FACILITIES. M. Gallay, G. Messe, J. Poittevin. CIGRE, 1982, paper 12-04. After a brief introduction into the component parts of a UHV shunt reactor, the authors examine its main design problems and then describe an installation and a power supply process allowing the performance of complete tests in the factory. (Abstract from article)

[1982] SR-009
EFFECT OF ZERO-SEQUENCE COMPENSATED UHV UNBALANCED SHUNT REACTOR ON SECONDARY ARC CURRENT AND RECOVERY VOLTAGE. I. Kurihara, Y. Sekine. Electrical Engineering In Japan (USA), vol. 102, no. 5, Sept.-Oct. 1982, pp. 84-85. The article proposes a method to evaluate the effect of a zero-sequence compensated unbalanced reactor on the secondary arc current and recovery voltage. The proposed method makes it possible to design the optimal shunt reactor taking into account the relative importance of various kinds of faults. (IEEE abstract, from Inspec)

[1983] SR-010
UHV SHUNT REACTOR FOR SECONDARY ARC EXTINCTION ON MULTIPHASE RECLOSING. Y. Sekine, I. Kurihara. International Journal of Electric Power and Energy Systems, vol. 5, no. 4, Oct. 1983, pp. 247-260. Secondary-arc suppression is necessary for successful fast, multi-phase reclosing on UHV lines. Installation of a shunt reactor is one of the most effective methods of rapidly extinguishing the secondary arc. For multi-phase reclosing on untransposed double-circuit UHV lines, a zero-sequence compensated balanced shunt reactor cannot suppress the secondard arc sufficiently due to the imbalance in electrical couplings among phases. A zero-sequence compensated unbalanced shunt reactor is proposed to compensate for the imbalance in the electrostatic couplings. The effects analysed by the introduction of phase-to-phase compensation parameters. Such parameters can be used to decide on the optimum shunt reactor for secondary arc extinction. (IEEE abstract, from Inspec)

SURGE ARRESTERS -SA-

[1970] SA-REF
DIELECTRIC STRESSES (in Italian). G. Carrara, A. Clerici. Elettrotecnica, vol. 57, no. 10, Oct. 1970, pp. 581-593. For abstract, see entry [1970] IC-003.

[1971] SA-REF
ASEA DEVELOPMENTS IN THE UHV FIELD. B. Thoren. ASEA Journal (Sweden), vol. 44, no. 5, 1971, pp. 109-117. For abstract, see entry [1971] PT-008.

[1971] SA-REF
REDUCTION OF SWITCHING OVERVOLTAGES IN EHV AND UHV SYSTEMS. H.B. Thoren. IEEE Transactions, PAS, vol. 90, no. 3, May-June 1971, pp. 1321-1326. For abstract, see entry [1971] IC-009.

[1972] SA-002
TEMPORARY OVERVOLTAGES AND PROTECTIVE REQUIREMENTS FOR EHV AND UHV ARRESTERS. A. Schei, A. Johansson. CIGRE, Aug. 1972, paper 33-04. Arresters operating in EHV systems have to guarantee lightning and switching surge protection and at the same time possess the ability to clear high temporary overvoltages. This is a contradictory situation especially at low protection levels. This report gives a general background for switching surge protection in contrast to clearing temporary overvoltages. The influence of arrester design and the location of arrester in the system is discussed. The voltage-current characteristic of the arrester is shown as important; essential design improvements are possible when compared with conventional gap arresters of today. Some fundamental requirements in arresters operating in EHV systems are also given. (Abstract from article)

[1975] SA-004
SOURCE IMPEDANCE CHARACTERISTICS AND THEIR EFFECT ON SURGE ARRESTER DESIGN. R.W. Flugum, J.W. Kalb. Transactions, South African Institute of Electrical Engineers, vol. 66, pt. 5, May 1975, pp. 90-104. The design and characteristics of surge arresters for high voltage transmission lines are discussed in detail. It is shown that the discharge currents of modern current-limiting gap arresters, although significantly affected by changes in source impedance, vary much less than their predecessors. Modern surge arrester follow current can reach the valve block infinite bus current when available short circuit exceeds 30 kA. The critical current capability of the current-limiting gap arrester is an important arrester characteristic in considering EHV and UHV line discharge requirements. Arrester durability requirements can differ considerably from that assumed by standard type tests. (Engineering Index abstract, from Compendex)

[1976] SA-005
REQUIREMENTS ON EHV AND UHV SURGE ARRESTERS: COMPARISON OF ENERGY AND CURRENT DUTIES BETWEEN FIELD AND LABORATORY CONDITIONS BY MEANS OF TNA SIMULATION. E.C. Sakshaug, A. Schei, A. Clerici, G.P. Mazza, G. Santagostino, A. Taschini. CIGRE, 1976, paper 33-10. The paper deals with requirements on EHV and UHV surge arresters with special reference to switching and temporary overvoltage operations. Different single-phase laboratory circuits for performance verification of surge arresters are studied, and comparisons with field conditions are made by means of TNA simulation. Pollution testing, as well as correlation between full scale and prorated testing, are also dealt with. (Engineering Index abstract, from Compendex)

[1976] SA-REF
GENERAL REPORT OF GROUP 33: OVERVOLTAGES AND INSULATION COORDINATION. G. Carrara. Electra, no. 49, December 1976, pp. 117-123. For abstract, see entry [1976] IC-029.

[1977] SA-006
MODERN ARRESTERS FOR EHV AND UHV NETWORKS--REQUIREMENTS AND TECHNICAL SOLUTIONS. U. Burger, R. Rudolph. Brown Boveri Review, vol. 64, no. 5, May 1977, pp. 290-296. Arrester requirements for EHV networks are considered. Quenching chambers of the type HS arrester are presented as a solution. The design and operation of the arrester are presented as well as tests indicating the arrester's excellent reseal capability. (Engineering Index abstract, from Compendex)

[1977] SA-007
A PROGRAM FOR UHV TRANSMISSION. H.N. Scherer, Jr., B.J. Ware, H.B. Thoren. American Power Conference Proceedings, vol. 39, 1977, pp. 1113-1120. The paper describes the development and the 1977 status of UHV transmission technique. Particular attention is paid to the following areas: system overvoltages and insulation requirements; corona; electric and magnetic fields; UHV conductors and support insulators; substation arrangements; transformers and reactors; surge arresters; circuit breakers; and relay protection. (IEE abstract, from Inspec)

[1977] SA-008
LYONS 1100/1200 kV GIS TEST PROGRAM, QUARTERLY REPORT NO. 4, JULY 1, 1977-SEPTEMBER 30, 1977. P.L. White. 1200 kV Prototype Transmission Line Project. Bonneville Power Administration, Portland, Oregon. An update is given on testing of Waltz Mill 1200 kV GIS equipment including Westinghouse and Ohio Brass surge arresters. (Abstract from report)

[1978] SA-009
ARRESTERS FOR SUBSTANTIAL LIMITATION OF OVERVOLTAGES IN 1100/500 kV SYSTEMS. A.I. Bronfman, V.F. Laslo, I. Shchelokov, S.S. Shur, N.N. Tikhodeyev, O.I. Yakovlev. CIGRE, 1978, report 33-06. The paper reports on the essential performance data of highly non-linear zinc oxide resistors and on electric circuit diagrams, design features and protection performance of gapless surge arresters (called by the authors "non-linear overvoltage limiters") using such resistors. Laboratory and network tests and operational experience with the new arresters are described. An assessment is given to the efficiency of their application as a means to lower the size and cost of 110-500 kV indoor and outdoor substations. (Abstract from article)

1978] SA-010
MORE RESEARCH NEEDED FOR SURGE ARRESTERS. O.S. Johansen. IEC Bulletin (Switzerland), vol. 12, no. 50, March 1978, pp. 1-2. The paper discusses surge arresters for protection against lightning strikes and switching surges in HV and UHV overhead power lines. (IEE abstract, from Inspec)

[1978] SA-011
OPERATING CONDITIONS OF SWITCHING SURGE ARRESTERS IN CONNECTING SHUNT REACTORS ACROSS SPARKGAPS (in Russian). M.L. Levinshtein, Yu. I. Kyskov, G.V. Chernova. Elektrichestvo, no. 8, Aug. 1978, pp. 5-11. The paper considers parallel arresters in clearing a single-phase short circuit and connection of a single-phase overhead line in the reclosure cycle, and reports results of computer study of 1150 kV line. The method of connection is found to reduce arrester current loadings and the expected and standard surge maxima in the middle part of the line. (IEE abstract, from Inspec)

[1978] SA-012
RELIABILITY/ECONOMICS DICTATE APPLICATION OF STATION ARRESTERS. J.C. Osterhout. Electrical Engineering (Australia), vol. 55, no. 3, March 1978, pp. 19-22. Better application decisions are made possible concerning station arresters on EHV and UHV systems and in unusual system circumstances. (IEE abstract, from Inspec)

[1978] SA-013
NEW CONCEPTS ON OVERVOLTAGE PROTECTION BY SURGE ARRESTERS. Y. Ozaki, M. Takanashi, S. Tsurumi, K. Mitani, M. Kobayashi. CIGRE, 1978, paper 33-02. This paper deals with new concepts of sparkover and operating duty characteristics which are critically important for the performance of surge arresters used in EHV and UHV power systems. In addition, various characteristics of newly developed gapless arresters offering improved protection are described. Tests performed in Japan on these 500 kV surge arresters produced good results, even though these tests were made under severe conditions as determined by the new concepts of overvoltage protection. It was verified that the gapless arresters have sufficient capacity to withstand severe operating duties when they are applied to an HVDC system. (Engineering Index abstract, from Compendex)

1978] SA-014
LYONS 1100/1200 kV SUBSTATION TASK FORCE QUARTERLY REPORT, JULY 1, 1978-SEPTEMBER 30, 1978. K.M. Watkins. 1200 kV Prototype Transmission Line Project. Bonneville Power Administration, Portland, Oregon. Potential modifications are described for 768 kV surge arresters: a 1 kV arrester section or a 10-inch spacer are possibilities. Also discussed are request for proposals from DOE for the development of shunt reactor designs for 1200 kV GIS. (Abstract from report)

[1978] SA-015
LYONS 1200 kV SUBSTATION TASK FORCE QUARTERLY REPORT 9, OCT. 1, 1978-DEC. 31, 1978. K.M. Watkins. 1200 kV Prototype Transmission Line Project. Bonneville Power Administration, Portland, Oregon. A modification to 768 kV surge arresters encompasses a 10-inch spacer inserted below the terminal pad and corona rings fitting. This increases distance to provide switching surge protection. Also included is information on switching, lightning impulse, and 60 Hz tests as performed on 768 kV surge arrester with all tests satisfactory. (Abstract from report)

[1979] SA-016
STUDY TO DETERMINE THE BASIC INSULATION LEVEL REQUIREMENTS FOR A PROTOTYPE 1200 kV CGIT CABLE SYSTEM. J.H. Cooper. Advanced Systems Technology Division, Westinghouse Electric Corp., Pittsburgh, Pennsylvania. DOE/ET-2061-1, contract no. EX-76-C-01-2061, July 1979. Available from NTIS. The required lightning impulse withstand characteristics of a prototype 1200 kV CGIT system were studied. It was assumed that lightning overvoltages would be introduced into the CGIT system due to lightning strokes which terminate on the overhead transmission system connected to the CGIT system. A detailed analysis of several proposed configurations of 1100/1200 kV transmission lines indicated that the most probable form of lightning overvoltage introduced into the CGIT system would be caused by shielding failures rather than blackflash occurrences. Following this conclusion, a single-phase digital transient program was utilized to calculate the transient overvoltages which would appear within the CGIT system for system lengths of 600 feet, 2 miles, 10 miles, and 50 miles. Part of these simulations modeled surge arresters at both ends of a CGIT system representing a cable system interposed in an overhead line or a cable system terminating at an air-insulated substation. A second group of computer simulations modeled a surge arrester at one end only to represent the situation where a CGIT system terminates at a gas-insulated station

where the disconnects are opened and no arrester is applied within the gas insulation. Two types of surge arresters were modeled in this study: (1) an arrester having protective characteristics extrapolated from present designs and (2) ceramic oxide arresters. (NTIS abstract)

1980] SA-017
SURGE ARRESTER FOR 1200 kV GAS-INSULATED SUBSTATION. J.W. Kalb. IEEE publication no. 79 CH 1399-5-PWR (SUP), 1980, pp. 244-250. A surge arrester for protection of 1200 kV gas-insulated stations is described. Protective and durability characteristics are given. The design uses metal oxide varistors and series gaps. A separate internal housing is not used. The design minimizes internal voltage grading and heat transfer requirements. (Abstract from article)

[1980] SA-018
1200 kV SUBSTATION TASK FORCE QUARTERLY REPORT, JULY 1, 1980-SEPTEMBER 30, 1980. R. Sarkinen. 1200 kV Prototype Transmission Line Project, quarterly report 16, Sept. 30, 1980. Bonneville Power Administration, Portland, Oregon. 1200 kV surge arresters supplied by General Electric and Westinghouse have been delivered and tested at the Ross High-Voltage Laboratory. The arresters were installed at the Lyons test site Sept. 15-18, 1980. The instrumentation was installed and checked and arresters energized on Sept. 19, 1980. Periodic arrester currents were measured and evaluation of the arresters for long-term operating stresses will continue. (Abstract from report)

[1980] SA-REF
OVERVOLTAGE PROTECTION AND INSULATION COORDINATION OF GAS-INSULATED SUBSTATIONS. A. Schei. Proceedings, The Brown Boveri Symposium: Surges in High-Voltage Networks, Baden, Switzerland, Sept. 3-4, 1979, published in Surges in High-Voltage Networks, Plenum, N.Y., 1980, pp. 345-504. For abstract, see entry [1980] IC-050.

[1981] SA-020
POWER FACTOR TEST ON 1100 kV ZnO SURGE ARRESTERS AT LYONS TEST SITE. C.R. Bock. Field tests on 1200 kV metal oxide surge arresters, April 9-17, 1981. Bonneville Power Administration, Portland, Oregon. Power factor tests with the 10 kV Doble set were performed on two Westinghouse 1100 kV and one General Electric 1100 kV ZnO surge arresters March 22, 1982. Measurements compared favorably with similar tests made March 6, 1981. These tests provide future reference values to alert testing personnel to significant changes in electrical characteristics of the arresters. (Abstract from report)

[1981] SA-021
INVESTIGATION OF FAILED OB 768 kV ARRESTER FROM LYONS TEST SITE, BPA NO. A4503. D.A. Bradley. 1200 kV Test Program progress report, Feb. 11, 1981. Bonneville Power Administration, Portland, Oregon. A summary of tests performed on the Ohio Brass arrester that failed August 8, 1980, indicate all sections failed internally. Disassembly and inspection revealed: 1) extensive fault current damage in grading circuit; 2) rust in top section; and, 3) evidence of long term heating of grading resistors in top section, most likely due to an unbalanced voltage distribution. (Abstract from report)

1981] SA-022
LABORATORY TESTS AFTER FACTORY REPAIR OF OB 768 kV FROM LYONS, BPA NO. A4505. D.A. Bradley. 1200 kV Test Program progress report, Sept. 11, 1981. Bonneville Power Administration, Portland, Oregon. After failing in service in February 1980, the Ohio Brass arrester was returned to factory for repair. Subsequently, laboratory tests found RIV and grading current levels acceptable but sparkover levels abnormally low on the middle and to sections and the complete stack. Minimum switching impulse on complete stack was 1060 kV. Increasing the diameter and lowering the height of the grading ring increased sparkover voltage 16 percent (minimum 1270 kV). Additional tests are needed on ring design. (Abstract from report)

[1981] SA-023
LABORATORY TEST ON OB 768 kV ARRESTER FROM LYONS, BPA NO. A4506. D.A. Bradley. 1200 kV Test Program progress report, Sept. 11, 1981. Bonneville Power Administration, Portland, Oregon. Removed from service March 1981, and replaced with a metal oxide arrester, BPA A4506 showed acceptable levels in 60 Hz RIV, grading current, sparkover, and switching impulse tests. Minimum switching impulse sparkover voltage on complete stack was 12 percent higher than in tests of October 1979 with no explanation for increase found. (Abstract from report)

[1981] SA-024
LABORATORY TESTS ON WESTINGHOUSE 700 kV METAL OXIDE ARRESTERS. D.A. Bradley. 1200 kV Test Program progress report, May 11, 1981. Bonneville Power Administration, Portland, Oregon. Laboratory tests were performed on two Westinghouse 700 kV (MCOV) metal oxide surge arresters which had been purchased by EPRI for long-term evaluation purposes. Before installation at BPA's Lyons test site, RIV, leakage current, 60 Hz voltage distribution, and impulse tests were performed. RIV levels were acceptable. Balanced voltage distribution was indicated with a less than 3°C rise above ambient. Impulse test results indicate a peak voltage of 1.55 per unit at 1000 A. (Abstract from report)

[1981] SA-025
SIXTY HERTZ TESTS AFTER FACTORY REPAIR OF WESTINGHOUSE 140 kV METAL OXIDE ARRESTER SECTION FOR LYONS. D.A. Bradley. 1200 kV Test Program progress report, Sept. 11, 1981.

Bonneville Power Administration, Portland, Oregon. This report summarizes the mechanical failure and the subsequent repair and 60 Hz tests of one 140 kV section of a Westinghouse 700 kV metal oxide surge arrester. Disassembly showed mechanical failure in one porcelain housing. After factory repair, RIV and leakage current test levels were satisfactory. (Abstract from report)

[1981] SA-026
DOBLE POWER FACTOR TESTS OF FIRST 1000 kV ZnO SURGE ARRESTERS INSTALLED AT LYONS TEST SITE. J.W. Connelly. 1200 kV Test Program progress report, Sept. 11, 1981. Bonneville Power Administration, Portland, Oregon. Doble power factor tests with a 10 kV test set were made on all three ZnO surge arresters after installation on the 1100 kV side of transformers. Benchmark values for capacitance and watts loss were thus established. One arrester is from General Electric and two are from Westinghouse. (Abstract from report)

[1981] SA-027
LEAKAGE CURRENT TESTS OF 1200 kV METAL OXIDE SURGE ARRESTERS. R.J. Denis. Field test of Lyons 1200 kV metal oxide surge arresters, April 9-17, 1981. Bonneville Power Administration, Portland, Oregon. All sections of the 1200 kV ZnO surge arresters at the Lyons test site were energized individually in place at voltages encompassing the maximum continuous rated voltages. The corresponding 60 Hz leakage currents were measured. These voltage levels duplicated original laboratory test levels. A precalibrated portable test supply and the onsite precision leakage resistors were used in conjunction with an oscilloscope and digital waveform analysis system to make the measurements. No significant differences in arrester leakage current characteristics were indicated compared to measurements made in the high-voltage laboratory prior to energization at Lyons in September 1980 and April 1981. (Abstract from report)

[1981] SA-028
KEEPING THE SURGES OUT OF THE CIRCUIT. R. Whitaker. EPRI Journal, vol. 6, no. 2, March 1981, pp. 24-28. An air gap forms the threshold resistance in most surge arresters; it withstands steady line voltage but is bridged by an arc when a damaging pulse must be shunted to ground. A new solid-state surge arrester has been developed that is capable of less-than-microsecond response time but big enough to handle the switching surge of an experimental 1200 kV power system or the overvoltage surge of a lightning bolt. It is faster, smaller, and cheaper; and it limits surges to lower levels. (Engineering Index abstract, from Compendex)

[1982] SA-029
INSULATION COORDINATION OF 1200 kV SYSTEMS WITH THE GAPLESS 1200 kV METAL OXIDE SURGE ARRESTER. A. Hileman, A. Sweetana, N. Hingorani, V. Tahiliani. Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 334-354. Available from Bonneville Power Administration. The paper outlines the development of a completely gapless 1200 kV metal oxide surge arrester. It then presents the protective characteristics of the arrester based on test data. These characteristics form the basis for a determination of the BIL/BSL levels required for the 1200 kV air-insulated stations. Approximate values of 2050/1600 kV appear to be reasonable. (Abstract from article)

1982] SA-031
USA EXPERIENCE WITH SURGE ARRESTERS ON EHV SYSTEMS: IMPLICATIONS FOR UHV SURGE ARRESTER APPLICATIONS. J.D.M. Phelps, E.J. Yasuda, J.C. Osterhout, E.C. Sakshaug, A.G. Yost. Third Symposium on EHVAC Power Transmission, US-USSR joint committee, published by Bonneville Power Administration, May 10, 1982, pp. 58-68. This paper briefly summarizes the general experience with arresters on EHV systems in the USA. More details are given on the 362 and 800 KV systems of the American Electric Power Company (AEP) and the 500 kV system of BPA. A discussion is included of the application of zinc oxide arresters to 1200 kV and 1600 kV UHV systems proposed by BPA and AEP respectively. (Abstract from article)

[1982] SA-032
DESIGN, DEVELOPMENT AND TESTING OF 1200 kV AND 550 kV GAPLESS SURGE ARRESTERS. A. Sweetana, N. Kunkle, N. Hingorani, V. Tahiliani. IEEE Transactions, vol. 101, no. 7, July 1982, pp. 2319-2327. The paper outlines the objectives of the EPRI development program on the 1200 kV and 550 kV gapless metal oxide arresters. Six important design considerations are described along with the verification testing involved with each. Final test results are presented on the individual arrester units as well as the complete 1200 kV and 550 kV poles. The gapless zinc oxide arrester offers the opportunity to re-examine the economics of insulation coordination and to look at new applications wherever voltage limiting or energy absorption is needed. (Engineering Index abstract, from Compendex)

[1983] SA-033
GAPLESS SURGE ARRESTERS FOR POWER SYSTEMS APPLICATIONS. VOL. 1: DEVELOPMENT OF 500 AND 1200 kV ARRESTERS. A. Sweetana, T. Gupta, W. Carlson, R. Grekila, N. Kunkle, J. Osterhout. EPRI final report EL-3166, research project 657-1, Sept. 1983. This research project--a team effort of the Westinghouse Research Laboratories and the Westinghouse Distribution apparatus Division--had four main objectives. (1) Investigate the basic scientific phenomena related to nonlinear ZnO ceramics. (2) Develop ZnO compositions and processes. (3) Design, build, and deliver two completely gapless 1200 kV voltage limiters to EPRI for field testing. The protective level in the switching surge time frame to be 1.5 per unit of maximum line-to-ground voltage.

(4) Deliver to EPRI, three completely gapless ceramic oxide voltage limiters for installation and field test on a 550 kV power system. As a beginning, the project developed materials and sources, characterization procedure, preparation and processes. Ball milling, mixing, spray drying, and pressing techniques were established. Voltage and thermal stability along the with nonlinearity and energy absorption capability were of prime concern, so several oxide constituents were investigated for effects on electrical, mechanical, and thermal factors. From a microstructure standpoint, the investigation involved scanning electron micrograph (SEM), energy dispersive X-ray analysis (EDAX), optical micrograph, and transmission electron microscope techniques. Selective etching procedures enables 3-dimensional stereo viewing of the intergranular lacy network. Scale up techniques of material handling, pressing, and sintering permitted manufacture of thousands of discs 11.7 cm diameter by 1.85 cm high. These were assembled into three 550 kV system arresters and two 1200 kV system arresters, tested, and shipped to EPRI-designated utilities. These were the world's first 1200 kV gapless arresters. EPRI project manager: V.H. Tahiliani. (Abstract from report)

[1983] SA-034

GAPLESS SOURGE ARRESTERS FOR POWER SYSTEMS APPLICATIONS. VOL. 2: BPA'S FIELD INSTALLATION AND EVALUATION OF 1200 kV ARRESTERS. E.J. Yasuda. EPRI final report, research project 657-1, EL-3166, Sept. 1983. Laboratory tests, long-term 60 Hz energization at BPA's Lyons UHV test facility, and staged switching tests--all were conducted on the EPRI UHV arresters. These arrester tests and evaluations demonstrated the following. (1) The thermal stability of the metal-oxide elements against 60 Hz operating voltage and under actual operating conditions for the period the arresters were energized. (2) The arresters performed switching impulse protective functions as designed and confirmed by the staged switching tests. (3) Within the measuring accuracies, the 60 Hz and impulse protective characteristics through laboratory tests agreed with factory test results. (4) The arrester design including the grading devices limited the RIV at the maximum continuous operating voltage to an acceptable level. Improvements on the surface finish of the grading devices would be helpful in minimizing the external RIV sources. (5) The design of the grading devices properly distributed the 60 Hz operating voltage across the individual units of the pole.. (6) The importance of proper arrester unit design and assembly to withstand external mechanical loads under operating conditions for arresters of the multi-unit and parallel column designs. EPRI project manager: V.H. Tahiliani. (Abstract from report)

[1984] SA-035

RECENT ASPECTS OF ZINC OXIDE LIGHTNING ARRESTERS. K. Nakano, J. Ozawa. Hitachi Review, vol. 33, no. 3, June 1984, pp. 157-160. Since their first application in 1975, zinc oxide lightning arresters (ZLAs), which use zinc oxide elements with excellent nonlinear voltage-current characteristics, have been widely spread throughout the world for transmission systems ranging from 3 kV to 500 kV. Recently, the performance of zinc oxide elements has been improved further and now it is expected that ZLAs for 1,000 kV UHV systems with even better protective performance will be developed in the near future. This paper described some technical improvements concerning Hitachi's recent ZLAs. (Engineering Index abstract, from Compendex)

[1968] PT-001
TRANSFORMERS (in German). V. Aigner. Elektrotechnische Zeitschrift, Ausgabe A, vol. 89, no. 19-20, Sept. 13, 1968, pp. 482-488. The present state of construction of large transformers is typified by 1000 MVA 3-phase banks, comprising single-phase poles for 400 kV and 420 MVA 3-phase generator transformers as well as 700 kV single-phase poles for 200 MVA power throughout. Since the present large transformers exceed the carrying capacity of available flatbed wagons, it will be necessary to make wagons for useful loads of about 450 T. In future transmission voltages will probably be higher than 1000 kV. Rising per unit powers and operating voltages require considerable outlay in manufacture and in test stations which lead to special arrangements, for example in the manufacture of cores and windings. (IEE abstract, from Inspec)

[1969] PT-003
UHV GAS-INSULATED TRANSFORMERS. H.C. Doepken, Jr. Proceedings: 9th Electrical Insulation Conference, Boston, Mass., Sept. 8-11, 1969, pp. 146-147. The primary advantages of gas transformers are: (1) high insulation strength without barriers; (2) negligible dielectric loss; and, (3) ease of field assembly. The primary disadvantage is that the convective cooling abilities of SF6 are worse than transformer oil. For the same temperature rise, SF6 will transmit about one-fifth to one-third the heat from a surface that oil will. At 50 lbs/in 2/ and 70°F the cost of SF6 is $2.90 cubic foot. Transformer oil is about $2.00 cubic foot. The gas is lighter, but the higher pressure requires a heavier and more costly tank. This paper describes the design and construction of an 870 kV, 870 kVA prototype gas transformer which also is used as a test transformer. A design for a gas-insulated 765/345 kV, 500 MVA single-phase autotransformer is also presented. (IEE abstract, from Inspec)

[1970] PT-004
REQUIREMENTS FOR 1150 kV EQUIPMENT. Yu. I. Lyskov. Published in "High Voltage Devices, Transformers, Power Capacitors," 2nd edition, 1970, Informelectro. (Abstract unavailable)

[1971] PT-005
CONCEPTIONS AND PROBLEMS IN THE CONSTRUCTION OF VERY-HIGH-VOLTAGE TRANSFORMERS (in German). R. Elsner. Elektrotechnische Zeitschrift, Ausgabe A, vol. 92, no. 12, Dec. 1971, pp. 683-688. After an introductory review of the foreseeable future development of 3-phase very-high-voltage transmission systems, there is a discussion of the requirements of the insulation arrangement of power transformers and the specification of the test voltages for operating voltages up to 1500 kV. The resulting stresses on the insulation can be dealt with up to the maximum anticipated voltages by suitable development of the main insulation and of the internal insulation of the windings. On the basis of designs for a 1200 kV test transformer with a nominal output of 400 MVA as well as for an 1100 MVA single-phase autotransformer with a transformation ratio of 1200/525 kV the present limiting powers from single-phase autotransformers and generator transformers are listed. (IEE abstract, from Inspec)

[1971] PT-006
ASEA PRESENT THE WORLD'S FIRST UHV POWER TRANSFORMER. P. Hessen. ASEA Journal (Sweden), vol. 44, no. 5, 1971, pp. 120-122. The paper describes the full-scale prototype for a 1000 MVA. 1500 kV power transformer built by ASEA for the testing of UHV shunt reactors and for performing realistic long-term tests for the evaluation of power transformers to be used in future UHV power systems. (IEE abstract, from Inspec)

[1971] PT-007
PROBLEMS IN EXTENDING TRANSFORMER TESTING PRACTICE TO THE MEGAVOLT RANGE. L.L. Preston. Residential Symposium On the Testing of Power Apparatus and Systems Operating in the Megavolt Range, University of Manchester, Sept. 20-24, 1971. The economic justification for UHV transmission is based to a considerable extent on lower costs per unit which result from the introduction of larger plant ratings. Transformers for UHV are likely to have higher MVA throughputs and weigh considerably more than existing units. This increases the testing requirements more than would be the case for normal high voltage laboratories concerned primarily with switchgear and overhead lines. (IEE abstract, from Inspec)

[1971] PT-008
ASEA DEVELOPMENTS IN THE UHV FIELD. B. Thoren. ASEA Journal (Sweden), vol. 44, no. 5, 1971, pp. 109-117. ASEA's development work in UHV field is taking place within the framework of the AEP-ASEA UHV research project. Principal aims are to explore the highest system voltages from theoretical and practical considerations and to develop systems and equipment for the selected range of feasible system voltages. ASEA's work on the development of UHV transformers, shunt reactors, circuit-breakers, surge diverters and instrument transformers is described. It is concluded that UHV apparatus can be built and that there does not seem to be any theoretical or practical upper voltage limit, at least not up to 1500 kV. (Abstract from article)

[1971] PT-REF
CONSTRUCTION OF THE HIGH-VOLTAGE LABORATORY AT IREQ (in French). J. Feltrin. Ingenieur (Canada), vol. 57, no. 273, Dec. 1971, pp. 3-8. For abstract, see entry [1971] TF-005.

[1972] PT-009
DESIGN PROBLEMS OF UHV POWER TRANSFORMERS. V.M. Chornogotsky, V.M. Makarov, L.N. Shifrin, I.D. Voevodin, A.K. Lokhanin, L.I. Milman, V.P. Zenova. CIGRE, 1972, paper 12-06. The report deals with the main design problems of 1150/500 kV autotransformers, insulation test voltage, research results of insulation models, winding arrangement schemes, and transport problems given the existing railway limitations. Preliminary considerations referring to autotransformers for voltages higher than 1150 kV are given. (Abstract from article)

[1972] PT-010
THREE-PHASE POWER TRANSFORMERS (in German). W. Dietrich, H. Heindl. Energie und Technik, vol. 24, no. 4, April 1972, pp. 118-124. Power transformer requirements are governed by the rising transmission voltages--up to 380 kV in Europe and 700 kV in USA and USSR--and by the increasing powers per station. The design and construction of iron cores, windings, insulation and transformer piece-parts are discussed. Several large and three-phase transformers are described, with specification details and operational features. Design recommendations are made for reducing the induction-dependent magnetorestrictive noise. Problems encountered during road and rail transport of large transformers are discussed. It is anticipated that in future, it may be possible to transport by sea large 2000 MVA power stations and 1500 kV single-phase transformers. (IEE abstract, from Inspec)

[1972] PT-011
THE DESIGN AND TRANSPORT OF VERY LARGE TRANSFORMERS. B.F. Hampton. CIGRE study committee 31, London, 1972. (Abstract unavailable)

[1972] PT-012
UHV POWER TRANSFORMERS: DEVELOPMENT AND TESTING. P. Hessen, B. Thoren. Canadian Communications & EHV Conference, Nov. 9-10, 1972, Montreal, IEEE publication 72 CHO 698-1-REG-7, pp. 151-152. The choice of transformer ratings and insulation levels for UHV systems is discussed. UHV transmission systems will have capacities of several thousand MVA. Three-phase banks of 3000-6000 MVA have been discussed for a 1500 kV system, which means single-phase units of 1000 to 2000 MVA. Transportation limitations will restrict the dimensions and weights of the units. The reports concludes: (1) a UHV prototype should contain full-scale core and windings to enable realistic conclusions from tests; (2) switching impulses do not trigger continuous partial discharges if the alternating voltage is not itself close to the partial discharge inception voltage; (3) no saturation effect for insulation withstand strength has been found for oil barrier insulation with increasing voltage and distance; (4) impurities--moisture and fibers--can considerably reduce the dielectric strength of oil-paper insulation; (5) calculated voltage distributions in UHV transformers windings agree with measurements on modules; (6) the air gap distances for UHV voltages can be considerably reduced by means of sufficiently large and suitably shaped electrodes; and, (7) transformers for system voltages up to at least 1600 kV with suitable ratings can be built and transported. (Abstract from article)

[1972] PT-013
EVOLUTION OF TRANSMISSION SYSTEM IN ITALY AND ADOPTION OF A NEW VOLTAGE LEVEL. L. Paris, F. Reggiani, M. Valtorta. Proceedings, Symposium on Long-Term Prospects of the Electric Power Supply Situation, Stockholm, Sweden, Sept. 11-13, 1972, vol. 2, paper STO/SYMP/EP/E. 7, pp. 1087-1113. This paper discusses the results of studies carried out by Italy's ENEL (Ente Nazionale per l'Energia Elettrica) to provide a basis for the choice of a new voltage level common to the whole of Europe. A comparison is made between two alternative developments with different voltage levels, 765 or 1050 kV to be superimposed on the present 420 kV network. Cost analysis justifies the choice of the 1050 kV system. The main characteristics of overhead lines (conductors, insulation distances, towers), electric stations and equipment (insulation, rated current and short-circuit levels) and transformers are given. (Engineering Index abstract, from Compendex)

[1972] PT-014
POWER TRANSFORMERS FOR SYSTEMS WITH A HIGHEST VOLTAGE BETWEEN 1100 AND 1500 kV. W. Rabus, W. Stein. CIGRE, 1972, paper 12-08. For the next step in transmission systems, voltages of 1100 kV up to 1500 kV are under discussion. This report describes investigations of specific conditions following from the voltage range for the insulation coordination with regard to the transformers and the choice of their insulation levels. The discussion includes influences of operation voltage and transportation feasibilities on the maximum unit rating of transformers as well as problems of adequate dielectric testing of the transformers. The demands on test equipment are mentioned briefly. The design of a 1200 kV, 800 MVA autotransformer is explained in detail and its behavior under different dielectric tests is shown. The report describes construction and testing of an experimental transformer to a 1:1 scale. (Abstract from article)

[1973] PT-015
UHV RESEARCH PROJECT INTERIM REPORT. Transmission and Distribution, vol. 25, no. 1, Jan. 1973, pp. 52-53. Results to date of the AEP-ASEA UHV research project indicate a switching surge level of 1.5 per unit is now considered feasible. UHV apparatus can be built. (A 1500 kV transformer has been built). Corona and induced effects can be controlled. No theoretical or practical limitation to voltage levels exists, at least up to 1500 kV. Indications are that even higher voltages can be obtained. (IEE abstract, from Inspec)

[1973] PT-016
METHODS AND MEANS OF VOLTAGE REGULATION OF LARGE AUTOTRANSFORMERS. B. Heller. Electra, no. 29, pp. 11-28. Regulating autotransformers connecting two UHV systems offer a number of problems decisive for their design. The author distinguishes a direct regulation using a regulating winding on the autotransformer and indirect regulation using a series regulating transformer. Important questions related to surge and short-circuit conditions, core flux variations and short-circuit voltage, as well as problems of testing and protection are considered. (IEE abstract, from Inspec)

[1973] PT-017
SOME ASPECTS OF BUILDING LARGE TRANSFORMERS. G.J. Hulsink. Holectechniek (Netherlands), vol. 3, no. 2, July 1973, pp. 42-51. Problems which arise in the design and construction of very large transformers are discussed. Attention is given to dimensions and transport weights within and outside the limits of the railroad profile, as well as to problems of electrical nature such as the choice between three- and five-limb cores. The choice of winding types, impulse voltage and short-circuit strength, especially regarding the insulation between turns in coils. Results of a heat-run test with the back-to-back method in a transformer with forced oil flow through the windings and natural flow through the core are mentioned. Attention is paid to the electric field. The author speculates on 3-phase transformers for about 2000 MVA and 1100 kV. (IEE abstract, from Inspec)

[1974] PT-018
DIELECTRIC TESTS OF EHV AND UHV TRANSFORMERS. Z.M. Beletsky, V.M. Chornogotsky, E.S. Frid, S.D. Lisunov, A.K. Lokhanin, A.F. Maximtsov, T.I.Morozova. CIGRE, 1974, paper 12-05. Problems dealing with dielectric switching impulse and long-duration power-frequency tests of EHV and UHV power transformers are considered. Test voltage values and permissible levels of partial discharges are proposed. (Engineering Index abstract, from Compendex)

[1974] PT-019
TRANSFORMERS FOR THE FUTURE 1000 kV SYSTEMS: PROBLEMS TO BE SOLVED AND RESEARCH IN PROGRESS (in Italian). A. Bossi. Elettrotecnica, vol. 61, no. 9, Sept. 1974, pp. 789-797. The article gives the characteristics that power-station transformers and interconnecting auto-transformers should have, as well as the service conditions expected during their life. The article also outlines the research concerning short circuit withstand, insulation and transportability. (IEE abstract, from Inspec

[1974] PT-020
TRANSFORMERS FOR THE FUTURE 1000 kV SYSTEM: PROBLEMS TO BE SOLVED AND RESEARCH IN PROGRESS (in Italian). F. Coppadoro. Elettrotecnica, vol. 61, no. 9, Sept. 1974, pp. 799-813. The report illustrates the research carried out on the 1000 kV prototype of autotransformers. The problems involved with their realization, e.g., study of specific stresses--and particularly dielectric stresses--are outlined. (IEE abstract, from Inspec)

[1975] PT-021
INFLUENCE OF SOLID IMPURITIES ON THE ELECTRIC STRENGTH OF TRANSFORMER OIL. F. Abgrall, J.M. Cardon. Proceedings, Conduct and Breakdown in Dielectric Liquid, 5th International Conference, Delft University of Technology Noordwijkerhout, Netherlands, July 18-31, 1975, pp. 79-83. The reduction of the overall size of UHV transformers can be obtained by increasing the electrical field in the insulation, especially in the oil. Therefore it is of paramount importance to know the breakdown voltage of the oil under various circumstances. Carefully controlled measurements of electric strength of degassed and filtered parameters are studied: the volume of oil under stress, the size of solid particles impurities. With aluminum electrodes in uniform field configuration, the electric strength of the oil is low if it is not filtered between successive breakdowns. Test results are explained on the basis of particles-initiated breakdown. (Engineering Index abstract, from Compendex)

[1975] PT-022
FLASHOVER CHARACTERISTICS OF TRANSFORMER OIL IN LARGE CYLINDER-PLANE ELECTRODES UP TO GAP LENGTH OF 200 mm, AND THEIR APPLICATION TO THE INSULATION FROM OUTER WINDING TO TANK IN UHV TRANSFORMERS. M. Higaki, K. Endou, Y. Kamata, M. Hoshi. IEEE Conference Publication C 75 116-9, July-Aug. 1975, p. 1097f. The insulation from outer winding to tank is one of the most important factors in the design of UHV transformers for the purpose of the solution of problems associated with high-voltage, high-rating and physical size. This paper describes the results of experiments on the flashover characteristics of transformer oil in a large cylinder-plane electrode, and its application to the insulation from outer winding to tank in UHV transformers. The main substance of our study is as follows: (1) breakdown voltages are measured within gap length of 200 mm in a 1200 mmo cylinder-plane electrode; (2) the probability distribution of the breakdown voltage of long gaps in the large cylinder-plane electrode is investigated; and, (3) the design concept of the insulation from outer winding to tank in UHV transformers is shown. It is concluded that ac and lightning impulse breakdown strength are almost constant in the range of gap length of 20 mm to 200 mm, and that the breakdown probability distribution of long gaps fits well with a Weibull distribution function. (Abstract from article)

[1975] PT-023
THE INFLUENCE OF EXCITATION ON LIGHTNING SURGES IN TRANSFORMER WINDINGS (in Polish). A. Ketner. Przeglad Elektrotechniczny, vol. 51, no. 11, Nov. 1975, pp. 446-450. The impulse voltage tests to which transformers are subjected before commissioning are carried out on unexcited units, whereas an operating transformer is exposed to voltage surges while it is excited. The higher peak value of a chopped impulse wave, substantial in the standard, among others, by the disadvantageous superposing of overvoltages due to the impulse voltage and an alternating voltage is questioned as regards UHV transformers. An approximate analysis of the effect of transformer excitation upon the insulation hazard due to lightning surges is presented. (IEE abstract, from Inspec)

[1975] PT-REF
GENERATION OF SWITCHING IMPULSES USING HIGH VOLTAGE TESTING TRANSFORMERS. H. Anis, N. Trinh, D. Train. IEEE Transactions, PAS, vol. 94, no. 2, March-April 1975, pp. 187-197. For abstract, see entry [1975] TF-010.

[1976] PT-024
MODERN DEVELOPMENTS IN LARGE DISTRIBUTION TRANSFORMERS AND TAP CHANGERS (in German). K. Gadek. Verband Deutscher Elecktrotechniker (VDE) Fachberichte, vol. 29, 1976, pp. 61-74. The principal topics dealt with in this survey are: liquid-cooled distribution transformers; compound-filled transformers; large transformers (windings, losses, core construction); UHV transformers; and tap-changing switchgear. (IEE abstract, from Inspec)

[1976] PT-025
VOLTAGE DISTRIBUTION IN IMPULSE EXCITED CASCADE TEST TRANSFORMERS (in German). H. Wehinger. Elektrotechnische Zeitschrift, Ausgabe A, vol. 99, no. 6, June 1976, pp. 332-335. The generation of switching impulses with cascaded testing transformers yields to a non-uniform voltage distribution across the stages. Investigations are done on cascades up to four stages as a model for UHV units. The cascade is energized either from the power supply, or from a capacitor on earth potential, or from potential free capacitors in every stage. Several possibilities to attenuate transient overvoltages are investigated and the results are compared. (Engineering Index abstract, from Compendex)

[1977] PT-026
VOLT-TIME RELATIONSHIP FOR PD INCEPTION IN OIL-PAPER INSULATION FOR UHV TRANSFORMERS. A. Bossi, S. Cesari, F. Coppadoro, S. Yakov. World Electrotechnical Congress, Moscow, June 1977, section 2, paper 42. Coordinating the insulation of UHV systems involves reduced ratios between insulation levels and service voltage. Thus, the design of internal transformer insulation depends to a greater extent on the ac stresses expected in service. Moreover, the higher rated power and voltage values concerned call for fuller utilization of the insulating materials. A more extensive knowledge of the behaviour of insulations under long-term ac stresses is therefore necessary for the establishment of correct criteria for both design and tests. In this field, many studies and experiments have been carried out in Italy within the framework of the 1000 kV project, with a view to the future introduction of this new voltage level. These studies have been conducted in cooperation between ENEL and the major Italian transformer manufacturers. This report deals with experimental research carried out on oil-paper insulated structures in order to investigate PD inception under steady-state ac voltage. (Abstract from article)

[1977] PT-027
THEORETICAL CONSIDERATION ON CORONA DISCHARGE IN POWER TRANSFORMER (in Japanese). T. Inque. Mem. Res. Inst. Sci. and Eng. Ritsumeikan Univ. no. 33, 1977, pp. 1-7. UHV has been recently used for power transmission lines as power consumption has been increasing. As a result, corona discharges are generated in some power arrangements. A theoretical study of such corona discharges in power transformers is presented. (IEE abstract, from Inspec)

[1977] PT-028
OVERVOLTAGES IN HIGH AND ULTRA-HIGH VOLTAGE TRANSFORMERS IN OPERATING CONDITIONS (in German). M.R. Kostenko, J.A. Michajlov, F.C. Chalilov. Elektrie (GDR), vol. 31, no. 10, 1977, pp. 529-530. As the power of the supply systems increase the individual performance of the power transformers must increase as well. At the same time the insulation reliability requirements and the dimensioning precision become stricter. Therefore the overvoltages to which a transformer is subjected must be determined with higher accuracy. (Engineering Index abstract, from Compendex)

[1977] PT-REF
A PROGRAM FOR UHV TRANSMISSION. H.N. Scherer, Jr., B.J. Ware, H.B. Thoren. American Power Conference Proceedings, vol. 39, 1977, pp. 1113-1120. For abstract, see entry [1977] SA-007.

[1978] PT-030
LIMITS OF TRANSFORMER CAPACITY (in German). Electrotechnik (Switzerland), vol. 29, no. 6, July 1978, pp. 50-60. The article refers to the part played by the transformer union development facilities in the increase of the maximum size of a 3-phase power transformer unit from 1000 MVA to 2000 MVA, and of working voltages up to 1500 kV; also in the development of tap changers rated from 200 to 3000 A and from 30 to 380 kV. Single-phase rectifier transformers of about 100 MVA, smoothing chokes of 0.83 H to carry 1800 A, and filter chokes for a +/-533 kV dc system have been supplied.

Transformers of ratios such as 15 kV/1 kV for high-speed locomotives now have ratings up to 7000 kW continuously. A new range of cast resin foil-wound transformers includes sizes up to 3 and 4 MVA. (IEE abstract, from Inspec)

[1978] PT-032
CHOICE OF THE CHARACTERISTICS OF POWER TRANSFORMERS FOR UHV SYSTEMS. A. Bossi, L. Giannuzzi, G. Manzoni, F. Coppadoro, G. Sigaudi. CIGRE, Aug. 1978, paper 12-11. The introduction of UHV systems mainly supplied by nuclear power stations will involve recourse to a new generation of power transformers. In choosing these units, account should be taken both of the needs of the system and of the difficulties to be faced in manufacturing transformers with advanced characteristics. The paper discusses the main ratings that step-up transformers and interconnection autotransformers should have, and stresses the advisability of providing reserve units in nuclear power stations. The need for transformer units with high reliability is emphasized. Experimental plants for research on the behavior of transformers should be provided well in advance of the introduction of a UHV system as scheduled in the planning studies. (Abstract from article)

[1978] PT-033
REDUCING THE SWITCHING TIMES DUE TO SHORT-CIRCUIT CURRENTS USING DISTANCE PROTECTION IN EHV/UHV TRANSFORMERS (in Czech). K. Kral. Energetika, vol. 28, no. 6, June 1978, pp. 247-251. The paper deals with coordination of protective equipment in a power system. A formula is derived for determining the coordination interval whose correct value safeguards selective switching of failures. Protection of EHV/UHV transformers by time-lag overcurrent protection is recommended to be replaced by distance protection. Conditions for operation of the distance protection (impedance and time setting, determining the ground coefficient) are analysed. (IEE abstract, from Inspec)

[1979] PT-034
DEVELOPMENTS IN THE UHV'S IN THE NEXT FIVE TO TEN YEARS IN REFERENCE SPECIFICALLY TO 1200 kV POWER TRANSFORMERS. P.L. Bellaschi. Doble Conference, April 1979, paper 46 AIC79, pp. 61-1-11. Studies of bulk power transmission at 1200 kV and above at loadings of 5000 MW per circuit and higher have been in progress since the late 60s. More recently, intensive economic studies have also been conducted, directed to specific projects that are foreseen at present to materialize in the next 10 to 15 years. There are cases, especially applications at 1200 kV, that may materialize even sooner, possibly within the next decade, depending on national events and circumstances. In view of these major industry developments and the key role power transformers will play, a brief review and a critical assessment of status and of the work ahead in this important area appear quite timely at this juncture. This is the primary purpose and objective of the present report, which concentrates on the development of 1200 kV power transformers and their application. However, the same considerations and basic approach apply equally to 1600 kV, or somewhat higher voltage, which in all probability would be the next voltage step. (Abstract from article)

[1979] PT-035
THE DEVELOPMENT OF UHV TRANSFORMERS (in Japanese). R. Tamura, H. Kan, T. Aoki, M. Hirai, E. Tamaki. Mitsubishi Denki Giho, vol. 53, no. 4, April 1979, pp. 304-307. The Mitsubishi Electric Corporation has been at work since 1975 on fundamental research to develop high reliability insulation for UHV transformers, and has recently developed a prototype with the primary objective of insulation verification testing. The article reports on this work, and discusses problems in UHV transformer development, and the measures taken to solve them. (IEE abstract, from Inspec)

[1980] PT-038
COMPREHENSIVE EVALUATION OF THE FAILURE OF LYONS 1200 kV C-PHASE TRANSFORMER. V.L. Chartier, D.W. McMullan, A.L. Gabriel, A.L. Courts, J.H. Brunke, S.H. Sarkinen. 1200 kV Project Report no. EL-80-9, Sept. 8, 1980, Bonneville Power Administration. On November 10, 1978, the C-phase 1200 kV transformer at the LYONS UHV Test Center experienced an internal flashover when the 230 kV shunt capacitors at Santiam Substation were being switched. This report gives a comprehensive evaluation of this failure from the time of the failure to the re-energization date of December 5, 1979. Included in the report are BPA and Westinghouse conclusions as to the cause of the failure, and recommendations to help prevent future failures. (Abstract from report)

[1980] PT-039
900 kV UHV TESTING TRANSFORMER FOR CENTRAL RESEARCH INSTITUTE OF ELECTRIC POWER INDUSTRY. T. Fujimoto, S. Saizen, H. Hanashima. Fuji Electrical Review, vol. 26, no. 1, 1980, pp. 2-6. Construction features and insulation design are outlined of the 900 kV UHV testing transformer intended for long distance high power transmission. (Engineering Index abstract, from Compendex)

[1980] PT-041
SETTING OF THE TERTIARY CIRCUIT IMPEDANCE SUPPRESSING THE FAULT CURRENT IN SIX-PHASE POWER TRANSMISSION SYSTEMS. SINGLE-PHASE CIRCUIT ANALYSIS (in Japanese). Y. Onogi, Y. Okumoto, K. Okumoto. Bulletin of the Faculty of Engineering of Hiroshima University, vol. 28, no. 2, March 1980, pp. 115-122. In UHV power transmission systems with a directly grounded neutral, the voltage rise on the unfaulted lines can be suppressed, while the fault current becomes very large when the fault occurs. The authors describe how the large

fault current and the voltage rise on the unfaulted lines can be suppressed by inserting impedance into the tertiary coil of the transformer. In this case, the transformers in the sending and receiving ends are of two types: those with two single-phase transformers per phase. The impedance is inserted in the tertiary coil and the secondary coils are connected in six phase. Variations of the load of the system have influence on setting the impedance value. As a result of the theoretical analysis, it is verified that the most efficient impedance is reached with value evaluated under no-load condition. (IEE abstract, from Inspec)

[1980] PT-042
TRANSIENT ANALYSIS OF THE DIRECT GROUNDED SIX-PHASE POWER TRANSMISSION SYSTEMS SUPPRESSING THE FAULT CURRENT. SINGLE-PHASE CIRCUIT ANALYSIS (in Japanese). Y. Onogi, T. Nagata, K. Okumoto. Bulletin of The Faculty of Engineering of Hiroshima University, vol. 28, no. 2, March 1980, pp. 105-113. In conventional UHV power transmission systems have some demerits on the electromagnetic induction effects and the power system stability because of the large fault current. In order to resolve these problems, the authors have studied the new 6-phase power transmission systems having three leg core transformers. The authors describe the transient phenomena of this 6-phase power transmission system when the fault occurs. For the better understanding of the basic characteristics in the system, the transient analysis of the single phase circuit which corresponds to one phase circuit of the 6-phase circuit is carried out by using the symmetrical component method. As a result, in comparison with the conventional three phase parallel double lines, it becomes evident that the fault current is well suppressed even for a transient period i.e., a few cycles after the fault occurs. See also vol. 28, no. 2, March 1980, pp. 115-122, described in entry [1980] PT-041. (IEE abstract, from Inspec)

[1980] PT-043
SWITCHING IMPULSE TESTS OF EHV AND UHV TRANSFORMERS. L. Thione, A. Bossi, E. Sesto, G. Sigaudi, A. Babare, A. Spinelli. IEEE Transactions, PAS, vol. 99, no. 2, March-April 1980, pp. 779-789. A switching impulse testing technique is described which basically consists in discharging a capacitor into the low voltage winding of the transformer through an additional inductance, so that the overvoltage is inductively transferred in the high voltage winding in the form of a slightly damped oscillation. Results of extensive tests, performed on both single-phased and 3-phase transformers and autotransformers, are reported, outlining the advantages afforded by the method with respect to other techniques. Simple mathematical expressions are derived which permit a sufficiently accurate predetermination of the test voltage, helping the user in selecting the proper test circuit parameters. (Engineering Index abstract, from Compendex)

[1980] PT-REF
OVERVOLTAGE PROTECTION AND INSULATION COORDINATION OF GAS-INSULATED SUBSTATIONS. A. Schei. Proceedings, The Brown Boveri Symposium: Surges in High-Voltage Networks, Baden, Switzerland, Sept. 3-4, 1979, published in Surges in High-Voltage Networks, Plenum, N.Y., 1980, pp. 345-504. For abstract, see entry [1980] IC-050.

[1981] PT-044
SWITCHING SURGE RESPONSE OF TRANSFORMER INSULATION DESIGNED ON THE BASIS OF POWER FREQUENCY PD INCEPTION VOLT-TIME CURVES. S. Cosari, S. Yakov. IEEE Transactions, PAS, vol. 100, no. 7, July 1981, pp. 3263-3273; IEEE preprint 81 WM 003-3. The paper presents the results of power-frequency and switching-surge tests performed on transformer insulation models. The power-frequency tests were performed for the purpose of determining the 'equiprobabilistic volt-time curves' for partial discharge inception in the insulation. On the basis of these curves and of the maximum power-frequency stresses to be expected in service, a nominal voltage was assigned to the insulation of the models. Various series of switching-surge tests were then performed in order to study the response of the models to such stresses. Switching impulses of an amplitude of up to 3.1 were superimposed on a base ac voltage, which level was varied from U_N to $2U_N$. The results obtained are considered of interest both for the design and the testing of EHV and UHV transformers. (IEE abstract, from Inspec)

[1981] PT-045
INVESTIGATION OF PARTIAL DISCHARGES GENERATED BY SWITCHING OVERVOLTAGES IN INSULATION OF EXCITED WINDINGS IN UHV TRANSFORMERS (in Polish). J. Galczak. Rozprawy Elektrotechniczne, vol. 27, no. 1, 1981, pp. 165-178. The paper deals with a controversial problem of what is called "sustained partial discharges" in an insulating system of transformer, i.e., the discharges produced by switching overvoltages and then sustained by a working voltage. The model investigations lead to the conclusion that in UHV transformers, discharges of that type cannot be produced in the simple sequence switching overvoltage (working voltage) but they can occur in the sequence switching overvoltage (temporary overvoltage) working voltage. (Engineering Index abstract, from Compendex)

[1981] PT-046
VERY-HIGH-VOLTAGE TRANSFORMER AND EQUIPMENT SPECIFICATIONS (in Russian). M.N. Khodzhaev. Izvestiya Visshykh Uchebnykh Zavedenii Elektromekhanika, no. 11, Nov. 1981, pp. 1185-1158. The article discusses, in general terms, the existing arrangements and future requirements for comprehensive very-high-voltage supplies in certain regions of the Soviet Union to satisfy specific industrial needs. The projects already under way, started within the eleventh 5-year plan, include the

design and construction of 1150, 750 and 500 kV ac supplies and 1500 kV dc supplies. The special design performance requirements of transformers, autotransformers, power-monitoring transformers and circuit breakers are discussed. (IEE abstract, from Inspec)

[1981] PT-047
MAY THE GIS SF6 INSULATION BE CONSIDERED AS SELF-RESTORING? B. Gaenger, J. Vigreux. Electra, no. 75, March 1981, pp. 31-39. The insulation of a high-voltage GIS results from a combination of a solid insulation ensured by various support insulators and a gaseous insulation provided by SF6 at a low pressure, usually below 5 or 6 bar. In occurrences with pressurized gas insulation, flashovers may appear in various points of the metal-enclosed equipment during tests either at the factory or at site prior to commissioning, at voltages below those specified. To select a method for insulation coordination testing, it is necessary to know whether the insulation of the metalclad equipment is self-restoring or nonself-restoring. In addition, random flashovers may ocur during dielectric tests on assembled GIS prior to commissioning. Dismantling to inspect or make replacements has economic impacts; the question is therefore whether the notion of self-restoring insulation, previously defined for factory testing, may also be applied to the tests before substation commissioning, irrespective of the voltage shape applied and--if subsequent to flashover--the equipment will be capable of sustaining the various voltage stresses occurring during service. (Abstract from article)

[1982] PT-048
THE FIRST AUTOTRANSFORMER FOR THE 1000 kV PROJECT. G. Caprio, G. Cannavale. Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 270-279. Available from Bonneville Power Administration. For the purpose of going thoroughly and reasonably--in advance--into the problems of autotransformer design, construction, and operation, ENEL invited a consortium of Italian manufacturers to build a prototype. Rail transportation requirements were taken into account as were rated power and substation characteristics. This report supplies information about the preliminary research and factory tests, as well as testing carried out at the Suvereto experimental plant. (Abstract from article)

[1982] PT-049
FUNDAMENTAL RESEARCH INTO HIGH VOLTAGES FOR FURTHER DEVELOPMENT OF ELECTRIC POWER DISTRIBUTION SYSTEMS. E. Gockenbach, W. Buch, M. Crucius, A. Diessner, H. Luehrmann. National Aeronautics and Space Administration, Washington, D.C., report BMFT-FB-T-82-004: ISSN-0340-7608, May 1982. In order to guarantee correct electric power distribution, the use of voltages between 765 and 1200 kV was investigated. This fundamental research was conducted in an 1800 kV outdoor test station. After describing the connection and protection devices of the three-stage high voltage generating transformer, and the tested equipment which has to withstand humidity, rain, dirt accumulation, snow, ice, and wind, the recording equipment and the transient measurements which result from breakdowns in the SF6 gas-insulated equipment and from flashovers in long air gaps, are presented. To limit the effects of high voltage oscillation, damping resistance and short circuiting equipment on the primary side of the transformers were used. In this way, the overvoltages were prevented from rising to dangerous levels. (NTIS abstract)

[1982] PT-050
ASSESSMENT OF TEST RESULTS OF PROLONGED INSULATION TESTS OF VERY HIGH VOLTAGE POWER TRANSFORMERS (in Russian). A.F. Gorbuntsov, V.V. Gurin, V.P. Mayakov. Izvestiya Visshykh Uchebrykh Zavedenii, Electromekhanika (USSR), no. 10, Oct. 1982, pp. 1229-1235. An account is presented of the introduction of the methods and of prolonged testing of very high transformers, after this manufacture. The test procedures followed were generally those laid down by the relevant government all-Soviet standards (GOST). The results of the testing of 500, 330-1150 kV transformers are described, listing symptoms of degradation of the insulation and location of partial discharges. A procedure is developed for assessing the test results, for an acceptable level of partial discharges set at $3X10^{10}C$. The results obtained are presented in block diagram form. (IEE abstract, from Inspec)

[1982] PT-051
DEVELOPMENT OF UHV TRANSFORMERS IN JAPAN. I. Miyachi, Y. Ozaki, M. Yasuda, S. Matsumura, K. Okuyama, H. Kan, H. Murata. CIGRE, 1982, paper 12-03. To meet the future increase in electric power demand in Japan, a UHV transmission project is now under investigation, and the first part of the UHV system is expected to be commissioned around 1990. As a part of the project, a UHV transformer development program is under way to study basic technologies using elemental models and 1000 kV class prototype transformers. This paper discusses the present status of the program. (Abstract from article)

[1982] PT-052
DEVELOPMENT OF EHV TRANSFORMERS BASED ON UHV TECHNIQUE. E. Mori, M. Hoshi. Hitachi Review, vol. 31, no. 3, June 1982, pp. 147-150. In preparation for the introductions of UHV power transmission to Japan in the 1990s, Hitachi has recently completed development of UHV insulation. Improvements in analytical techniques and elemental model tests have aided the development of this new 'hybrid insulation.' Both UHV analytical techniques and hybrid insulation are also central to the design of 500 kV, 1000/3 MVA transformers.

This paper presents the test results for components of the UHV transformers, and construction and features of the recently developed more compact EHV transformer with reduced losses. (IEE abstract, from Inspec)

[1982] PT-053
800 kV STEP-UP TRANSFORMERS FOR GURI HYDROELECTRIC POWER STATION, VENEZUELA. E. Toyota, T. Kojima, M. Ichikawa. Toshiba Review (Japan), no. 140, July-Aug. 1982, pp. 12-17. Step-up transformers rated at 800 kV have been completed for GURI Hydroelectric Power Station, Venezuela. They are the first practical units exceeding 500 kV made in Japan amd are rated at 805.5 MVA as a 3-phase bank. They are the result of developmental research on UHV transformers and technological experience gained on large-capacity transformers in Toshiba. Specific features, techniques applied and construction are discussed. (IEE abstract, from Inspec)

[1983] PT-054
PROBLEMS OF LONG-TERM RELIABILITY FOR UHV TRANSFORMER INSULATION. T. Yanari, M. Honda, M. Ikeda, Y. Taniguchi, Y. Ebisawa. IEEE Transactions, PAS, vol. 102, no. 6, June 1983, pp. 1693-1701. Through long-term (3 years) partial discharge (pd) tests on some component models for transformer insulation, the authors have revealed that transformer insulation has a threshold voltage, V_0, below which no partial discharge will occur regardless of how long the voltage may last. The value of V_0 is more than 62.5 percent of a 50 percent probability pd inception voltage at one-minute ac test. The authors also studied the characteristics of pd triggered by superposing switching impulses on ac voltage. The results have shown that no partial discharge can be triggered if the applied ac voltage is less than 1/1.4 of the pd inception voltage. A new concept of determining an appropriate ac dielectric test is presented. (IEE abstract, from Inspec)

[1984] PT-055
NEW TECHNOLOGY FOR LARGE POWER TRANSFORMERS. T. Fukuda, M. Hoshi. Hitachi Review, vol. 33, no. 3, June 1984, pp. 137-140. Hitachi has completed development of UHV (1,000-1,500 kV) techniques. New EHV single-phase autotransformers (1,000/3 MVA and 1,500/3 MVA) based on these techniques have been manufactured and put into operation: 800 kV 805. 5/3 MVA single-phase transformers and a 525 kV 1,200 MVA three-phase transformer for the nuclear power station. In order to keep transformers operating normally, preventive maintenance techniques have become more important than before. This article introduces these new techniques. (Engineering Index abstract, from Compendex)

[1984] PT-056
ALLOWING FOR THE REQUIREMENTS OF A POWER SYSTEM IN CHOOSING THE PARAMETERS OF ELECTRICAL MACHINERY AND TRANSFORMERS (in Russian). B.N. Neklepaev. Wissenschaftliche. Zeitschrift, Technische, Hochschule Ilmenau, vol. 30, no. 3, 1984, pp. 141-144. A general discussion stresses the importance of a systematic approach to the problem of optimizing nominal ratings of equipment in networks from 35 kV to 1150 kV. (IEE abstract, from Inspec)

[1984] PT-057
DEVELOPMENT OF UHV PROTOTYPE TRANSFORMER AND ITS APPLICATION TO 500 kV TRANSFORMER. K. Okuyama, E. Mori, M. Hoshi, Y. Kashima, M. Kitajima, Y. Kamata. IEEE winter meeting, 1984, paper 162-4. This paper describes dielectric test result of insulation model and prototype transformer after presenting necessity of development and principle of insulation structure for UHV transformer. New interleaved windings having gradual apportionment of series capacitances was developed, and proved that is has approximately uniform voltage distribution for lightning impulse and high reliability on dielectric characteristics. Insulation structure for UHV transformer was applied to 500 kV transformer, and its floor space, weight and loss were reduced about 20 percent compared to conventional 500 kV transformer. (Abstract from paper)

[1984] PT-058
CONTRIBUTION TO THE CHOICE OF THE DIELECTRIC WITHSTAND LEVELS OF SF_6 GAS-INSULATED SUBSTATIONS. A. Bargigia, A. Porrino, G. Rizzi, G. Santagostino, G. Mazzoleni. CIGRE, 1984, paper 33-13. The report deals with the insulation coordination problem of metal-enclosed gas insulated substations with specific reference to the internal fast transients generated by disconnector operations. Some aspects of digital simulation of fast transient are discussed. The results are compared with the experimental measurements. A method for estimating overvoltage levels in actual substations is presented. This is based on a statistical model of the disconnector, derived from capacitive switching tests. The strength of industrial components of EHV GIS under the composite voltage (dc + impulse) stresses are evaluated. The overvoltages caused by disconnector switching and lightning, as expected in service, are compared with the rated withstand levels specified by existing standards. (Abstract from article).

[1968] CVM-REF
1000 kV TESTING TRANSFORMER FOR N.V. KEMA (in Dutch). J.M.H. Claessen, P.B. Versteegen. Smit. Meded, vol. 23, no. 3, Sept. 1968, pp. 99-111. For abstract, see entry [1968] TF-001.

[1971] CVM-001
FORMATION OF NANOSECOND PULSES OF HIGH VOLTAGE. G.A. Mesyats, A.S. Nasibor, V.V. Kremnev. Formirovanie Nanosekundnykh Impulsov, 1970, pp. 1-153, translation at Foreign Technology Division, Wright-Patterson Air Force Base, Ohio, report no. FTD-HC-23-385-71, Nov. 2, 1971. Available from NTIS. The document is devoted to the design and construction of devices producing pulses lasting from one to hundreds of nanoseconds of voltage ranging up to 1000 kV. A survey is given of the existing methods for generators of high-voltage nanosecond pulses are discussed followed by an analysis of transient processes within the framework of equivalent circuits. Engineering calculations are included for the formative elements of various types of generators. The paper considers circuits correcting pulse waveforms, and also to circuits used to measure pulse parameters. (NTIS abstract)

[1972] CVM-REF
EVOLUTION OF TRANSMISSION SYSTEM IN ITALY AND ADOPTION OF A NEW VOLTAGE LEVEL. L. Paris, F. Reggiani, M. Valtorta. Proceedings, Symposium on Long-Term Prospects of the Electric Power Supply Situation, Stockholm, Sweden, Sept. 11-13, 1972, vol. 2, paper STO/SYMP/EP/E. 7, pp. 1087-1113. For abstract, see entry [1972] PT-013.

[1973] CVM-REF
UHV RESEARCH PROJECT INTERIM REPORT. Transmission and Distribution, vol. 25, no. 1, Jan. 1973, pp. 52-53. For abstract, see entry [1973] PT-015.

[1973] CVM-REF
METHODS AND MEANS OF VOLTAGE REGULATION OF LARGE AUTOTRANSFORMERS. B. Heller. Electra, no. 29, pp. 11-28. For abstract, see entry [1973] PT-016.

[1975] CVM-004
UNCONVENTIONAL METHODS OF CURRENT DETECTION AND MEASUREMENT IN EHV AND UHV TRANSMISSION SYSTEMS (USE OF OPTICAL AND E.M. TRANSFORMERS). M.N. Rzewuski, M.Z. Tarnawecky. IEEE Transactions, IM, vol. 24, no. 1, March 1975, pp. 43-51. The use of optical and electromagnetic current transformers for protection and measurement in EHV transmission systems is outlined along with salient specifications imposed by diversification of present-day applications. Basic principles of operation and typical applications of optical and electromagnetic current transformers are presented. (IEE abstract, from Inspec)

[1977] CVM-007
INSTRUMENTS FOR MEASUREMENTS OF ULTRA-HIGH VOLTAGES (in German). M. Juergen, J. Freitag, U. Brand, S. Shihab, H. Krauss. Bundeminist Forsch Technol Forschungsber Technol Forsch Entwickl, no. 77-56, Dec. 1977. The report describes the development, construction, and testing of a test transformer for ultra-high ac voltages. The most important partial problems solved under this project were: suitability for outdoor use due to the development of a ribbed insulating cylinder, calculation of the necessary screening electrode, low partial discharge intensity over the complete voltage range, high impulse withstand capability, for instance in the case of a steep voltage breakdown due to disruptive discharges on the test object, and generation of switching impulse voltages with test transformers. (Engineering Index abstract, from Compendex)

[1980] CVM-009
ELECTRONIC CURRENT TRANSDUCER FOR EHV CIRCUITS. L.E. Berkebile. EPRI final report EL-1611, Nov. 1980. As EHV and UHV grow, a need arises for better current measuring methods. Conventional live-tank current transformers become much larger and more costly as voltage withstand requirements become higher. Better accuracy is desirable as larger power flow occurs on interties between power systems. Improved high frequency response is required for advanced high speed relaying techniques and for current limiter operation. Previous current transducers have fulfilled some, but not all, of these requirements. This project intends to provide an electronic current transducer that meets present and projected requirements. The specific objective project was development of an electric current transducer with (1) amplitude error less than 0.3 percent; (2) dynamic range of twenty times rated current; (3) 10 kHz frequency response; (4) less than 100 mu s turn on time; (5) digital output; and, (6) utilizing fiber optic data transmission for EMI free operation. The project objectives have been met except that turn-on-time is 200 microsec. The transducer developed utilizes a conventional current transformer and shunt to provide a reference signal to the electronic encoding system. The encoder power supply is obtained from a current transformer on the transmission line. No auxiliary power supply is required. The encoded data signal is transmitted serially over a single conductor optical fiber cable to the station control room, a distance of up to 300 meters. The signal is decoded and converted to parallel digital output and an

analog output signal is reconstructed too. This analog signal provides +/-10 V output to represent full-scale peak line current. (NTIS abstract)

[1980] CVM-REF
FUNDAMENTAL RESEARCH INTO HIGH VOLTAGES FOR FURTHER DEVELOPMENT OF ELECTRIC POWER DISTRIBUTION SYSTEMS. E. Gockenbach, W. Buch, M. Crucius, A. Diessner, H. Luehrmann, A.G. Siemens. Report BMFT-FB-T-82-064: ISSN-0340-7608, Berlin, Germany, Dec. 1980. Available from NTIS. For abstract, see entry [1980] TF-015.

[1981] CVM-010
HVAC INSTRUMENT SYSTEM FOR GAS-INSULATED COAXIAL LINES, FINAL REPORT. G.J. Carlson, F.A. Fisher, J.M. Houston, R. Nakata, D.C. Peroutky. U.S. Department of Energy contract no. AC01-76ET29661, report DOE/ET/29661-1, Oct. 1981. This program was conducted for the development of metering quality, 0.3 percent accuracy class, current, and voltage instrumentation for an advanced 1200 kV gas-insulated power transmission system. This instrumentation is designed and uniquely adapted to the geometry of the coaxial line. The physical objective of the program is a test section of 1200 kV coaxial gas bus containing prototype instruments for measuring line current (1 per unit = 3000 A, 60 Hz), line voltage (1 per unit = 693 kV, 60 Hz line-to-ground) and for injecting and receiving carrier power (about 10 W) at frequencies typically in the 100 kHz to 500 kHz range. In addition to a metering specification, current and voltage instrumentation must respond to transient conditions with sufficient bandwidth (about 5 kHz) for use in protective relaying or measuring fault transients. The design fabrication and testing of the measuring instruments and associated electronic equipment for signal amplification are described. Test results indicate the system will meet the requirements of both revenue metering, 0.3 percent class, and protective relaying. Outputs of the signal amplified channels are typically 3 to 5 V rms at normal line power and are suitable for metering or driving static relays and other low-load-burden (2000 omega) devices. Initial field tests are planned at EPRI's Waltz Mill Cable testing facility near Pittsburgh, Pennsylvania. (NTIS abstract)

[1983] CVM-011
MAGNETIZATION CHARACTERISTIC OF COMBINATION CURRENT-TRANSFORMER MAGNETIC CIRCUIT. V.I. Rudenko, Elektrotekhnika (USSR), vol. 54, no. 2, 1983, pp. 16-18. Translated in Engineering (USA), vol. 54, no. 2, 1983, pp. 24-29. Current transformers (CT) of the electromagnetic type have found application in the measurement of transient current during short circuits on high-voltage (330-1150 kV) networks. Combination current transformers have a magnetic circuit which is constructed as a combination comprising two toroidal magnetic circuits. The principal and the auxiliary magnetic circuits, differing in length and the number of nonmagnetic gaps; the primary winding runs through the center of the torus while the secondary, common to both magnetic circuits is distributed uniformly over them. A method is given for calculating the magnetization characteristic of a combination current-transformer magnetic circuit, allowance being made for the actual distribution of magnetic flux in the zone of the nonmagnetic gaps. (IEE abstract, from Inspec)

STATION DESIGN & OPERATING EXPERIENCE -STA-

[1968] STA-001
1100 kV STATION AND LINE INSULATION DESIGN. J.K. Dillard, A.R. Hileman, J.P. McKinnon. CIGRE, 1968, paper 25-06. Switching surge and impulse tests were performed to permit design of an 1100 kV station to supply an underground transmission test facility. Using a 1.6 per unit switching surge design criteria, the support tower for the high-level bus has a 7.45 meter minimum strike distance, with a 0-unit post insulator (7.5 m in length) hung from the truss. Nine post insulators will be used in the station lower bus. Switching surge test results provided data to assess the design of 1100 kV systems. Comparison of the lightning, contamination, and switching surge requirements shows it is not technically feasible to design for switching surge levels greater than 1.6 per unit using present design philosophy. Contamination requirements many be a greater problem in stations than for transmission lines. Research is immediately required on (1) the breakdown mechanism of large-spaced gaps; (2) methods of reducing the surge applied to a system; and, (3) contamination. (Abstract from article)

[1972] STA-003
SHIELDING OF CONTROL CABLES IN POWER STATIONS. N.G. Trinh. Canadian Communications & EHV Conference, Montreal, Nov. 9-10, 1972, IEEE publication no. 72 CHO 698-1-REG-7, pp. 116-117. Transmission of low level signals for control or monitoring purposes in a HV power station is subjected to disturbances induced to the cables. This paper discusses the general problems of induction and the conventional techniques used to minimize the induced voltages. (Abstract from article)

[1975] STA-004
ELECTRIC FIELD AS A PARAMETER OF 750-1500 kV LINE AND SUBSTATION DESIGN: MEASURING METHODS, DESIGN PRACTICES, AND PLANS FOR FUTURE INVESTIGATIONS. G. Balderson, L.E. Zaffanella. Proceedings of the Symposium on EHV AC Power Transmission, US-USSR committee, Feb. 17-27, 1975, Washington, D.C., published by Bonneville Power Administration, pp. 77-100. The electrostatic and electromagnetic field produced by high-voltage current carrying conductors may cause effects to be considered in design of lines and substations. Currents, voltages, and energies may be introduced into humans, animals, vegetation, and objects. Of most concern is the emission from EHV/UHV projects. Correlation of the magnitude of the field existing at or close to ground level--in the absence of a recipient object--is the volatage gradient which is then taken as the design quantity. How measurements are made, the relation of power frequency current flow and object shape, energy released in spark discharges, fuel ignition potential from spark discharges--all are aspects of research that are addressed in this article. (Abstract from article).

[1975] STA-005
SWITCHING SURGE FLASHOVER CHARACTERISTICS OF LONG SPHERE-PLANE GAPS FOR UHV STATION DESIGN. H.M. Schneider, F.J. Turner. IEEE Transactions, PAS, vol. 94, no. 2, March-April 1975, pp. 551-560. The switching-surge behavior of UHV station electrodes was studied by investigating the performance of sphere-plane gaps. Design curves which show the effect of electrode curvature on the critical flashover voltage for spheres ranging in diameter from 0.5 to 2.5 and with gap spacings between 1 and 11 meters are presented. The influence of waveshape on large electrode flashover characteristics was obtained by varying the time-to-crest of the applied waveforms between 75 and 1220 us. Test data are given for smooth and segmented spheres during dry conditions. The effect of precipitation on the switching-surge strength was investigated by wetting the sphere surfaces either by natural rain or artificial means. The results presented provide information required for the switching-surge design of outdoor UHV stations. (Abstract from article)

[1975] STA-REF
REQUIREMENTS FOR GAS-INSULATED EQUIPMENT THROUGH 1980. R.E. Friedrich. American Power Conference Proceedings, vol. 37, 1975, pp. 1128-1135. For abstract, see entry [1975] SW-027.

[1976] STA-REF
SUBSTATION EQUIPMENT: PROJECTED NEEDS FOR THE NEXT VOLTAGE STEP. R. Flugum. IEEE Region Six (Western USA) Conference on Energy for the Future, Tucson, Arizona, April 7-9, 1976. For abstract, see entry [1976] SW-029.

[1976] STA-007
DESIGN OF SUBSTATIONS FOR SYSTEMS OPERATING AT 765 kV AND 1050 kV. C.W. Mott, D.F. Oakeshott, Y. Porcheron, G. Rivet, G. Mazza, A. Taschini. CIGRE, 1976, paper 23-12. The possible needs for development in England, France and Italy of transmission systems operating at 765 or 1050 kV are reviewed. Open-air and metalclad designs of substations are compared including their relative costs. The main design features of substations for operation at these voltages are examined with particular emphasis, at the present stage, on the open station. Reliability analysis as an aid to selection fields are computed and their effects assessed for appropriate station layouts. (Engineering Index abstract, from Compendex)

[1977] STA-009
GIS EQUIPMENT FOR UHV PROBLEMS AND NEEDS. R.W. Flugum, T.F. Garrity, J.P. Vora. World Electrotechnical Congress, Moscow, June 1977, paper 67. Another step in transmission voltage above 800 kV appears necessary if large concentrations of generation continue to be located at sites remote from load centers. Also evident, from 1200 kV test stations in operation and under construction, is that substations for these voltages will be gas insulated because of size and height considerations. Although many lower voltage gas substations are in service, most of the equipment in these stations is similar to equipment used in outdoor air insulated installations and, as such, is not optimized for use in a gas environment. Design changes, most of them departures from conventional practices, are necessary. This approach will result in maximizing the environmental advantages possible, thus the transition from air to gas will be complete and involve the entire station. (Abstract from article. See also entry [1976] STA-006 for related presentation.)

[1977] STA-REF
RESEARCH AND DEVELOPMENT. J.G. Harlow, Jr. Electrical Power Systems Research, vol. 1, no. 1, Sept. 1977, pp. 1-7. For abstract, see entry [1977] IC-035.

[1977] STA-REF
A PROGRAM FOR UHV TRANSMISSION. H.N. Scherer, Jr., B.J. Ware, H.B. Thoren. American Power Conference Proceedings, vol. 39, 1977, pp. 1113-1120. For abstract, see entry [1977] SA-007.

[1978] STA-010
MODEL FOR THE READY DEFINITION AND APPROXIMATE COMPARISON OF ALTERNATIVE HIGH VOLTAGE TRANSMISSION SYSTEMS. Commonwealth Associates, Inc., Jackson, Michigan, DOE/ET/5916-1, contract no. ET-78-C-05-5916, Dec. 1978. A model of generic overhead transmission systems in the range of 362 to 1200 kV ac, and +/-400 to +/-800 kV dc is developed. Such generic systems are to include: (1) transmission from generation to load; and, (2) interconnection of two large integrated systems, with and without the existence of an underlying, lower voltage network in either case. The model provides a means whereby an engineer with some experience in power systems planning can make a reconnaissance study of alternatives within a relatively short span of time and with fair accuracy. Given an amount of power to be transferred over a specified distance, the model can be used: to define the workable alternatives in terms of voltages, number of lines, series compensation, and certain other factors affecting transfer capability; to delineate other salient features of the selected alternatives, notably shunt compensation requirements; and to compare the alternatives in terms of potentially relevant benefits and costs. The significant properties of the model, the basis and assumptions necessary to its formulation, instructions for its use, and inherent limitations upon the accuracy to be expected are described. (NTIS abstract)

[1978] STA-011
ITALIAN 1000 kV PROJECT AND RELATED TEST FACILITIES. E. Bagala, F. Galli, C. Malaguti, L. Paris, M. Sforzini, M. Valtorta. CIGRE 1978, paper 31-16. After an analysis of the reasons that have led Enel to take an active interest in studies and research in the file of UHV transmission, the paper illustrates the plans and aims of the "1000-kV Project", a research and development program for the study and design of the future Italian UHV transmission system being carried out by Enel in cooperation with Italian manufacturers. In particular, the paper describes the experimental facilities for the project and presents the test programmes scheduled for the future. (Abstract from article)

[1978] STA-012
AEP-ASEA UHV RESEARCH PROJECT: TEST LINE AND STATION DESIGN. J.H. Provanzana, T. Adielson, E.J. Hatfield, A.L. Keeler, K. Klybas. IEEE Transactions, PAS, vol. 97, no. 5, Sept.-Oct. 1978, pp. 1853-1861. This paper elaborates the characteristics and details of the UHV line structures and hardware, the station layout and equipment and the reasons for their selection. The AEP-ASEA UHV station and line has been operating successfully for almost one year now. (AEP refers to American Electric Power Service Corporation; ASEA refers to Allmanna Svenska Elektriska Aktiebolaget, of Sweden.) Voltages as high as 2258 kV/√3 on a steady basis have been generated. Much more research and testing work will have to go forward, but the research effort into UHV has been enhanced by the building of the AEP-ASEA facilities. (Abstract from article)

[1978] STA-013
MODEL STUDY OF ELECTRIC FIELD EFFECTS IN SUBSTATIONS, FINAL REPORT, VOL. I. S.A. Sebo. EPRI report EL-632, Jan. 1978. Energized scale models of EHV/UHV substations can be used as design tools to determine the electric field distribution in and around the substation. To prove the method, an energized scale model of the Bixby Road 345 kV substation of Columbus and Southern Ohio Electric Company has been designed and built in order to compare the electric field distribution of the original substation with the substation model. The instrumentation and modeling problems and their solutions, calibration and verification tests are reviewed, and the accuracy of the model measurements discussed. Comparison of corresponding test points shows that the agreement between substation and model measurements is good: the mean of absolute values of errors is about 4.6 percent. In the course of the study, the electric field strength of the model was mapped for the base case, and the effects of a wide range of modifications were studied. Modifications included changes of equipment (circuit

breakers), switching operations, position (height and spacing) of buses, position of ground wires, transmission line sag, phasing of bays, application of shielding wire mesh, introduction of masts of different heights and changes in the layout of the substation. The feasibility of short circuit (charging) current measurements on model vehicles has also been proven. This modeling technique is detailed in a separate appendix and is available upon request from EPRI. Any utility having a need to determine the electric field distribution in or around substations will find this technology to be a useful design tool. (NTIS abstract)

[1979] STA-014
EVALUATION, DESIGN, DEVELOPMENT AND DELIVERY OF A 1200 kV PROTOTYPE TERMINATION. J.S. Billings, Z. Neri, J.R. Meyer, J.P Burkhart, E.P Donohue. Third Technical Progress Report, May 1, 1979-Aug. 31, 1979, DOE contract no. ET-78-C-01-3107, Sept. 1979. Detailed analytic and model studies of various termination concepts underway during the present period are described. Reduced scale models are being constructed for the electrostatic and the mechanical studies. Sample tests on a glass fiber reinformed insulating material show promise of an improved shatter-resistant weathercase material. Thermal analysis show that most of the termination designs being considered appear to have acceptable thermal profiles. Optimal materials, configurations, and fabrication plans are expected to be determined upon completion of these studies. (NTIS abstract)

[1980] STA-015
MAIN DESIGN SOLUTIONS FOR THE FIRST 1150 kV SUBSTATIONS IN THE USSR AND THEIR MAIN EQUIPMENT. S.V. Biryukov, I.M. Bortnik, G.K. Visnayakov, A.A. Vionov, E.G. Troyan, Y.A. Yakub. CIGRE, Aug. 1980, paper 23-07. This paper describes the main aspects of design of the first 1150 kV substations in the USSR, including switchyard schemes and designs. Data are given on insulation levels of the 1150 kV equipment. An autotransformer, a circuit-breaker and a circuit-breaking-and-making device rated for 1150 kv are described. (Abstract from article)

[1980] STA-016
FIRST 765 kV SF6 STATION PROVES SUCCESSFUL. R. Matulic, L.M. Laskowski. Electrical World, vol. 194, no. 3, Aug. 1, 1980, pp. 44-47. The experience gained by American Electric Power Service Corp. during the design, construction, and operation of the world's first 765 kV gas-insulated substation (the Joshua Falls Station) proves the effectiveness of this design. Although the cost effectiveness of SF6-insulated design increases as the voltage level increases, the combined cost of the 765 kV station and its associated 138 kV station was greater than the cost of equivalent air-insulated substations. Two novel design additions to the station significantly improve its reliability: (1) a mechanical finger, designed to give positive indication of the amount of ground-switch contact makeup; and (2) an alarm system, designed to warn an operator as he makes an error anywhere in an operating sequence. (IEE abstract, from Inspec)

[1980] STA-017
ULTRA-HIGH VOLTAGE SUBSTATIONS. E. Turies, J. Vigreux. CIGRE, Aug. 1980, paper 23-11. The installation of electric networks ranging between 1000 kV and 1600 kV is being contemplated in several countries. The prospective characteristics of the equipment equipping the UHV substations, such as insulation level, breaking capacity, interrupting time, etc., have been emphasized. Both competing techniques--i.e., air insulation and gas insulation experienced for voltages up to 800 kV--are studied and compared in this paper. A UHV air-insulated substation offers the advantage of raising no essential technical problems besides corona effect. The telescopic disconnect switches resorted to permit a more adequate use of the overhead space. Similarly, metering instruments transmission through fiber optics or electromagnetic waves must necessarily be used. As to the UHV GIS, its prominent qualities are as follows: compactness, insensitivity to pollution, no radio interferences. When choosing between these two techniques, considerations of cost will play a prominent part. Hybrid substations do not seem to rank very highly owing to the considerable number of insulating bushings required, and these bushings are quite expensive at UHV. (Abstract from article)

[1980] STA-REF
ALLOWING FOR NON-EQUIPOTENTIALITY OF EARTHINGS IN CALCULATING THEIR ELECTRIC PARAMETERS. A.I. Yakobs, T.T. Konobeeva. Elektrichestvo (USSR), no. 1, 1980, pp. 61-62, translated in Electric Technology USSR (UK), no. 1, 1980, pp. 165-168. For abstract, see entry [1980] IC-052.

[1981] STA-018
STANDARDIZATION AND CHOICE OF VOLTAGE LEVELS IN THE FIELD OF UHV WITH REFERENCE TO THE SITUATION IN THE WORLD. L. Paris, M. Valtorta. Seminar on High-Voltage AC/DC Transmission, Vigyan Bhavan, New Delhi, India, Dec. 18-19, 1981. The functions of UHV are briefly recalled by making reference to the conclusions of the "roundtable" on UHV transmission held at the 1980 CIGRE meeting. Economic and environmental reasons that justify their use are illustrated. The problem of the selection in a country of a new voltage level (in the UHV range) is then examined and the importance is stressed that this choice should be related to the already existing EHV voltage level. A ratio of about 2.3-2.5 is suggested between this two volatage levels, thus leading to the conclusion that for countries having at present networks at 420 kV or at 525 kV the choice of the future levels among the various foreseen by the IEC standardization should be respectively 1050 kV and 1200 kV. (Abstract from article)

[1981] STA-REF
VERY-HIGH-VOLTAGE TRANSFORMER AND EQUIPMENT SPECIFICATIONS (in Russian). M.N. Khodzhaev. Izvestiya Visshykh Uchebnykh Zavedenii Elektromekhn, no. 11, Nov. 1981, pp. 1185-1158. For abstract, see entry [1981] PT-046.

[1982] STA-019
RESEARCH PROGRAMS ON UHV SF6 SUBSTATION EQUIPMENT. A. Bargigia, L. Lagostena, G. Mazza, L. Centurioni, B. Mazzoleni. Ultra-High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 254-269. Available from Bonneville Power Administration. This report summarizes the present status of studies carried out to define the electrical stresses on 1050 kV metalclad substation components. The more significant results of extensive testing programs at present under way are then presented: they concern especially the dielectric strength of SF6 insulation, the aging of solid insulating materials, and the consequences of an arc inside the enclosure caused by an internal fault. Lastly, the report describes the prototypes made so far and the pilot plant on which UHV equipment field tests will be performed. (Abstract from article)

[1982] STA-020
SUBSTATIONS FOR UHV SYSTEMS. A. Bargigia, P.A. Cauzillo, L. Giannuzzi, G. Mazza, B. Mazzoleni. Ultra-High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 245-253. Available from Bonneville Power Administration. The development of transmission networks with voltages higher than 765 kV and the possible introduction in Italy of a 1050 kV transmission system have given rise to an examination of the problems confronting manufacturers and users when UHV interconnection substations have to be set up. In particular, the development of metalclad substations with SF6 insulation poses the problem of how far, and under what conditions, this technique is more economical than the conventional one. The purpose of this report is to make a contribution to the subject by analysing the problems that occur in the layout and construction of 1050 kV substation with air and SF6 insulation. (Abstract from article)

[1982] STA-021
FIRST RESULTS OF TESTS ON A 1100 kV CABLE SYSTEM. A. Bossi, F. Farneti, E. Dotti, G. Luoni. Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-18, 1982, Portland, Oregon, pp. 280-287. Available from Bonneville Power Administration. The paper refers to the design, development, and trials of a 1100 kV self-contained, oil-filled cable system, operated at high pressure. It has been designed to transmit about 3300 MVA per circuit, with separate pipe-cooling and 9100 MVA with conductor-oil cooling. The first results of tests carried out at the Suvereto Experimental Station in Italy are presented, in order to assess the main characteristics of both cable and accessories. (Abstract from article)

[1982] STA-022
SYSTEMS OF DISTRIBUTION NETWORKS (in Hungarian). H.C. Muller. Villamossag, vol. 30, no. 2, Feb. 1982, pp. 51-56. Essentially a distribution network satisfies the demand of lower level networks, serves as a reverse for higher level systems and supplies consumer requirements. Aspects of selecting the configuration of a distribution network are discussed. The voltage levels for the supply of large cities in Germany range from 0.4 through 10(20), 110, 380 to 1200 kV. Schematics of basic distribution networks grouped as closed, open and coupling systems and their derivatives are outlined. Public distribution networks are subject to continuous modifications due to higher power demands, changing short-circuit requirements, need for higher availability, advance in technology and change of environment. Discussed are specific costs of cables, overhead lines and high medium voltage substations. (IEE abstract, from Inspec)

[1982] STA-023
EXPERIENCE GAINED FROM OPERATING THE LYONS 1200 kV SUBSTATION. E.J. Yasuda, V.L. Chartier, A.L. Gabriel. Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 288-300. Available from Bonneville Power Administration. The test facility at Lyons was built to gain longterm experience operating and maintaining a prototype 1200 kV transmission line. This report summarizes experience related to substation equipment since energization in 1977. Also included are the audible noise and electric field measurements within the substation. The equipment includes both transformers and surge arresters, both designed to meet testing needs and not necessarily of commercial capacity. (Abstract from article)

[1982] STA-REF
800 kV STEP-UP TRANSFORMERS FOR GURI HYDROELECTRIC POWER STATION, VENEZUELA. E. Toyota, T. Kojima, M. Ichikawa. Toshiba Review (Japan), no. 140, July-Aug. 1982, pp. 12-17. For abstract, see entry [1982] PT-053.

[1983] STA-024
DEVELOPMENT OF UHV GIS IN JAPAN. E. Haginomori. Proceedings, CESI Symposium, 1983. This article describes the basic requirements and developing works of UHV GIS facilities. The technique developed in these can be applicable to not only UHV systems but also lower voltage ones. (Abstract from article)

[1983] STA-025
UHV AC SUBSTATION DESIGN CRITERIA SUMMARY OF WORLD TRENDS. R. Matulic, A.L. Courts, P.R. Dolan, J.J. Kolb, F.J. Jaskowiak, A.A. Liebolt, J.A. Maneatis, L.M. Laskowski, R.C. St. Clair, J. Sabath, J.P. Vora. IEEE Tranasactions, PAS, vol. 102, no. 3, March 1983, pp. 513-520. To determine major trends in substation design practices for alternating current voltages above 800 kV, a

survey was made and responses received from major utilities and or consultants, and manufacturers worldwide. For easier comparison the responses are tabulated; they are current to August 1981. This information will serve as a permanent record of the status of knowledge at present and will be of value to the user and the supplier who may be contemplating systems in UHV ranges. (Abstract from article)

[1983] STA-026
DOE R&D PROGRAM ON UHV SUBSTATION EQUIPMENT ACCOMPLISHMENTS AND CHALLENGES. J.P. Vora, K.W. Klein. Ultra High Voltage Transmission Technology, Italy-USA Joint Workshop, July 26-28, 1982, Portland, Oregon, pp. 314-327. Available from Bonneville Power Administration. Significant progress has been made in the development of 1200 kV compact gas-insulated substation components through the DOE/EES-sponsored research effort. Equipment of interest includes: power transformer and shunt reactor, voltage and current sensing device, circuit-breaker and disconnect switch, coaxial bus, termination and surge arrester. The R&D effort also includes fundamental research in gaseous dielecttrics and fault sensing and disgnostic techniques. This paper presents a status report on various projects including accomplishments and the technological challenges yet to overcome. (Abstract from article)

[1984] STA-REF
CONTRIBUTION TO THE CHOICE OF THE DIELECTRIC WITHSTAND LEVELS OF SF_6 GAS-INSULATED SUBSTATIONS. A. Bargigia et al. CIGRE, 1984, paper 33-13. For abstract, see entry [1984] PT-058.

[1968] TF-001
1000 kV TESTING TRANSFORMER FOR N.V. KEMA (in Dutch). J.M.H. Claessen, P.B. Versteegen. Smit. Meded, vol. 23, no. 3, Sept. 1968, pp. 99-111. The basic design of the 1000 kV HV testing transformer (4*250 kV in cascade) is first described, especially the compensation of capacitive currents by means of core gaps. A description is given of how the equivalent network for the cascade arrangement was derived from that of a normal three-winding transformer. On the basis of this equivalent network, computer calculations were made of the current and voltage distribution, the impedance and the number of resonant frequencies, in accordance with Kirchhoff's Laws. Some calculated and measured values are compared. Following the description of the construction of the magnetic circuit and the windings, details are given of the construction of the whole assembly. The electrical stresses in the different insulation constructions are described with the aid of field plots. The electrical diagram of the complete installation shows the various connection possibilities. (IEE abstract, from Inspec)

[1969] TF-002
HIGH-VOLTAGE ELECTRICAL TESTING OF POWER EQUIPMENT. A.S. Husbands. Journal of Science and Technology, vol. 36, no. 1, 1969, pp. 42-48. The facilities of the laboratory are described with particular reference to the test and development work which is required for power equipments. The facilities include a 1500 kV R.M.S. 50 Hz transformer-testing set, a 5 MVP 312 kJ impulse generator, and a variety of other testing and measurement equipment. The arrangement and purposes of the equipment is explained, and examples of high voltage investigations are included. (IEE abstract, from Inspec)

[1969] TF-003
WALTZ MILL FACILITY ADVANCES UHV SUBSTATION RESEARCH. F.S. Young, L.B. LeVesconte. Electrical World, April 28, 1969, pp. 38-41. Building the Waltz Mill facility provides for accelerated life tests on underground transmission samples for use on power systems up to 765 kV. It serves as an essential tool in the research program of the Electric Research Council. Added significance lies in the fact that the facility provides an opportunity to design and develop realistic station and apparatus for future transmission systems to operate at voltage levels of 1100 kV or higher. Several vital points have been brought out by work on the facility: (1) a real need to control switching surges to permit reasonably economical insulation structure design for systems above 500 kV, as well as need to investigate materials and grading techniques to improve switching surge withstand characteristics; (2) a need to develop new system design philosophy to enable system to tolerate higher number of flashovers; (3) consideration of using the same "compartment" concept that permitted significant savings at Waltz Mill to save on structure height for future 1100 kV substations. Overall, construction of the facility gives experience in stringing six-conductor bundles, in erecting four-conductor rigid bus, and in handling other construction problems--all of which will add to knowledge of 1100 kV system requirements. (Abstract from article)

[1970] TF-004
PROBLEMS AND ACTUAL LIMITS OF TESTING TECHNIQUES AT EXTRA HIGH VOLTAGES. A.F. Metraux. Transactions, South African Institute of Civil Engineers, vol. 61, no. 8, Aug. 1970, pp. 436-441. The rapid expansion of transmission systems into the fields of ultra-high tension up to 1500 kV and the advent of dc systems of very high voltage require the development of larger and more powerful testing transformers, rectifiers and impulse generators, as well as larger buildings to house them. The paper discusses the latest developments in testing techniques and problems arising to meet requirements at the very high test voltages. (IEE abstract, from Inspec)

[1971] TF-005
CHARACTERISTICS OF HIGH POWER LABORATORY SUPPLIED BY A 735 kV NETWORK. A. Dupont, J. Aubin. IEEE Conference Record: International Symposium on High Power Testing, July 21-23, 1971, Portland, Oregon. This paper summarizes the particular analysis that has been made through the design of a high power laboratory to meet present and future needs. Test requirements, flexibility and investment were the main criteria for this design. The laboratory facilities should permit studies and testing of nearly all electrical apparatus, such as transformers, reactors, protective equipment and switchgear which are integral parts of a distribution system and/or a 1500 kV future transmission network. Physical layout is discussed, as well as the electrical single line diagram to suit the requirements. (IEE abstract, from Inspec)

[1971] TF-006
CONSTRUCTION OF THE HIGH-VOLTAGE LABORATORY AT IREQ (in French). J. Feltrin. Ingenieur (Canada), vol. 57, no. 273, Dec. 1971, pp. 3-8. The laboratory is for testing transformers and other equipment rated up to 1500 kV. It has three buildings--the grand hall, annex and an office block--all forming part of the Institute de Recherche de L'Hydro-Quebec. The grand hall is a steel trellis structure (300 feet by 250 feet by 190 feet high) with double walls 12 feet thick, but hollow. To obtain the best possible flexible control of temperature and humidity inside the hall with minimum

displacement or circulation of air when tests are being carried out, the double wall system is subdivided into eight horizontal zones. The grand hall and annex have a joint copper bar trellis system making them into one large Faraday cage. (IEE abstract, from Inspec)

[1972] TF-007
MULTI-STAGE SYNTHETIC CIRCUIT FOR EXTRA-HIGH-VOLTAGE CIRCUIT BREAKER TESTING. V. Zajic, G. St.-Jean. IEEE Transactions, PAS, vol. 91, no. 3, May-June 1972, pp. 782-790. A new synthetic testing circuit intended mainly for EHV circuit breakers tests is being described. Based on the well-known idea of parallel current injection method, the circuit is created in the form of several integrated stages. The adjustment of the circuit test voltage to the rated voltage of the tested breaker is made by connecting the stages in series, in parallel or in a series-parallel combination. This arrangement creates a special type of a combined current and voltage impulse generator. After describing the new circuit diagram and its operation, the authors give the results of the work accomplished to date. This includes: (1) an analysis of possible disturbances caused by improper triggering of the spark gaps results of development of the spark gaps triggered, via a light beam, by plasma guns; (2) a short description of an experimental 3-stage circuit which is now prepared for tests; and, (3) an outline of the final testing circuit for voltages up to 1500 kV and equivalent 3 PHI symmetric interrupting capacity of 60000 MVA at T.R.V. frequencies as low as 680 Hz. (IEE abstract, from Inspec)

[1973] TF-008
NEW LARGE-TRANSFORMER ASSEMBLY BUILDING FOR THE TRANSFORMER UNION (in German). K. Rangs. Elektrotechnische Zeitschrift, Ausgabe A, vol. 94, no. 2, Feb. 1973, pp. 125-127. Details are given of the construction of the buildings, completed in 1972, including a 1500 kV testing bay and provision for the assembly of transformers of up to 3000 MVA rating. (IEE abstract, from Inspec)

[1973] TF-009
THE NEW HIGH POWER LABORATORIES AT LES RENARDIERES (SWITCHGEAR TESTING). M. Magnien, M. Pouard. American Power Conference Proceedings, vol. 35, 1973, pp. 1058-1064. Electricite de France has built at Les Renardieres a new UHV laboratory permitting indoor testing of equipment up to 1200 kV (rated voltage) and outdoor testing of equipment up to 1700 kV (rated voltage). This new UHV laboratory has been operating since 1970. (IEE abstract, from Inspec)

[1975] TF-010
GENERATION OF SWITCHING IMPULSES USING HIGH VOLTAGE TESTING TRANSFORMERS. H. Anis, N. Trinh, D. Train. IEEE Transactions, PAS, vol. 94, no. 2, March-April 1975, pp. 187-197. High-voltage switching impulses may be generated from cascaded testing transformers by suddenly energizing the transformers for a short period of time. A detailed analysis of this high-voltage impulse generation technique was made the its practical feasibility was tested on three transformer units in cascade. A series of generalized curves correlating the basic characteristics of the output impulse with the circuit components was derived for a rapid selection of the optimum operating conditions of any given test circuit. (Engineering Index abstract, from Compendex)

[1976] TF-011
THREE-PHASE TESTING FACILITIES AT EPRI'S PROJECT UHV. M.G. Comber, J.R. Doyle, H.M. Schneider, L.E. Zaffanella. IEEE Transactions, PAS, vol. 95, no. 5, Sept.-Oct. 1976, pp. 1590-1599. A description is given of the expanded facilities at Project UHV for the study of UHVAC transmission up to 1500 kV. These include a 3-phase test line for full-scale tests on a large variety of line configurations, three single-phase transformers for 1500 kV line-to-line, much associated electrical and mechanical equipment, and instrumentation for the acquisition of electrical and meteorological data. The 3-phase UHV test line has been energized since January 1975 and full-scale testing on 1000-1500 kV transmission lines is in progress. (Engineering Index abstract, from Compendex)

[1977] TF-012
ELECTRICITE DE FRANCE AND THEIR EXTRA HIGH TENSION LABORATORY (in Spanish). G. Leroy. Rev. Electrotec., no. 243, 1977, pp. 48-52. The aims of the laboratory are to study and prove the materials required for operations at 765 to 1500 kV. These tests include: (1) dielectric tests at industrial frequencies in dry weather and under thunder storm conditions on switch gear and cable runs; (2) dielectric tests under vibration produced by radiation and shock operation on transformers, stunt reactances, air insulators and switchgear; (3) dielectric tests under combined waveforms and shock operation to simulate interphase voltage surges; (4) checking RF perturbation levels and partial discharge levels; (5) tests on the behavior of insulation under artificial contamination; and, (6) tests on the mechanical strength of switchgear. The functions and equipment--of various bays in the laboratory for tests under indoor and open air conditions--are described.

[1977] TF-013
UHF-EQUIPMENT: TEST TRANSFORMERS FOR VERY HIGH VOLTAGES, FINAL REPORT (in German). J. Moeller, J. Freitag, U. Brand, S. Shihab, S.H. Krauss. Messwandler Bau G.M.B.H., Dec. 1977. Available from NTIS. The development, construction, and testing of a test transformer for ultrahigh ac voltages are described. Such transformers--as a three-stage cascade suited for the generation of ac

voltages of up to 2400 kV--are indispensable, for instance, in the testing of UHV equipment. The most important partial problems solved under this project were: suitability for outdoor use due to the development of a ribbed insulating cylinder, calculation of the necessary screening electrode, low partial discharge intensity over the complete voltage range, high impulse withstand capability, for instance in the case of a steep voltage breakdown due to disruptive discharges on the test object, generation of switching impulse voltages with test transformers also when connected in cascade, theoretical determination (proved by measurements) of the harmonic content of the generated high voltage in dependence of the load, and suitability of the insulating-shell design transformers for relatively high continuous output powers. On the basis of the design data established under this research project, it was possible to build an 800 kV prototype and subject it to a detailed test program. A proposal for improvement to increase the performance characteristics of the final design is included. (NTIS abstract)

[1980] TF-014
THE FUTURE TESTING NEEDS OF GAS-INSULATED SUBSTATIONS. T.F. Garrity, J.P. Vora. 2nd International Symposium on Gaseous Dielectrics, March 1980, p. 389f. (Abstract unavailable)

[1980] TF-015
FUNDAMENTAL RESEARCH INTO HIGH VOLTAGES FOR FURTHER DEVELOPMENT OF ELECTRIC POWER DISTRIBUTION SYSTEMS. E. Gockenbach, W. Buch, M. Crucius, A. Diessner, H. Luehrmann. A.G. Siemens. Report BMFT-FB-T-82-064:ISSN-0340-7608, Berlin, Germany, Dec. 1980. Available from NTIS. To guarantee correct electric power distribution, the use of voltages between 765 and 1200 kV was investigated. This fundamental research was conducted in an 1800 kV outdoor test station. After describing the connection and protection devices of the 3-stage high-voltage generating transformer--and the tested equipment which has to withstand humidity, rain dirt accumulation, snow, ice, and wind--the authors describe recording equipment and the transient measurements which result from breakdowns in the SF6-gas-insulated equipment and from flashovers in long air gaps. To limit the effects of high voltage oscillation, damping resistance and short circuiting equipment on the primary side of the transformers were used. In this way, the overvoltages were prevented from rising to dangerous levels. (NTIS abstract)

[1980] TF-016
TRANSFORMER REQUIREMENTS FOR THE YEAR 2000. Westinghouse Electric Corp., Pittsburgh, Pennsylvania, DOE/RA/3291-01, contract no. ET-78-C-01-3291, June 1980. Available from NTIS. The principal objective of this program was to determine the design parameters required for transformers of the year 2000. The approach to meeting this objective was to determine the changes which may occur in transmission and distribution systems over the next twenty years, and how these changes might affect design parameters of distribution and power transformers. Emphasis was placed on domestic requirements, although the impact of international practices was factored into the overall requirements for transformers. Possible investigations that could help transformer designers meet the long term technical requirements of future transformers were also identified. The principal conclusions of this study were: (1) 1200 kV transmission could be in service by the late 1980s and it is essential to develop 1200 kV transformers for these systems; (2) transformer manufacturers must be prepared to supply higher MVA ratings at all voltage levels; (3) there will be a strong demand for low-loss, minimum cost transformers; and, (4) environmental/safety, reliability, and size reduction considerations will increase in importance. (NTIS abstract)

[1981] TF-017
THE ROLE OF TEST CENTERS IN THE DEVELOPMENT OF UHV TRANSMISSION SYSTEMS. G. Carrara, S. Rovelli, L. Thione, V. Villa. Seminar on High Voltage AC/DC Transmission, Vigyan Bhavan, New Delhi, India, Dec. 18-19, 1981. There is no doubt that a UHV system cannot be designed only on the base of extra polation of experience with lower voltages, but ad hoc development work, both theoretical and experimental, is required. The role of the testing center is just to provide the necessary tools, and expertise in their use, for this development work. In this respect there is an element which must be considered and namely the fact that, when UHV enters the picture, HV or EHV test centers already exist. This leads to various alternatives: create a new UHV center, convert the EHV into UHV, extend the existing center to cover UHV, make a mixture of the first and third case. The case that will be examined in the following belongs to the "mixture" alternative, since the UHV Test Station of Suvere was created, while extensions were made of the existing CESI EHV Center in Milano. (Abstract from article)

[1981] TF-REF
AC FLASHOVER CHARACTERISTICS OF LONG AIR GAPS AND INSULATOR STRINGS UNDER FOG CONDITIONS. K. Takasu, N. Aria, Y. Imano, T. Shindo, T. Seta. IEEE Transactions, PAS, vol. 100, no. 2, Feb. 1981, pp. 639-645. For abstract, see entry [1981] IC-054.

[1982] TF-018
TESTING FACILITIES FOR DEVELOPING UHV EQUIPMENTS. M. Yamamoto, M. Honda. IEEE Transactions, PAS, vol. 101, no. 7, July 1982, pp. 2314-2318. The testing facilities of a UHV laboratory are described in this paper. The voltage rating of testing facilities and dimensions of the laboratory for developing UHV substation equipments, especially transformers and gas-insulated equipments, are discussed on

the basis of research and development experiences of UHV equipment manufacture. It has been determined that a 5000 to 6000 kV impulse voltage generator and a 2000 to 2300 kV testing transformer are required, and that practical dimensions of the UHV laboratory are 30 to 40 meters in width and 60 meters in length. (Engineering Index abstract, from Compendex)

[1982] TF-REF
UHV SHUNT REACTORS: TECHNICAL PROBLEMS AND TEST FACILITIES. M. Gallay, G. Messe, J. Poittevin. CIGRE, 1982, paper 12-04. For abstract, see entry [1982] SR-008.

[1983] TF-019
DESIGN OF MODULAR UHV AC OUTDOOR TEST SYSTEM. J.R. Booker, D.K. Nichols, W. Larzelere. IEEE Transactions, PAS, vol. 102, no. 8, Aug. 1983, pp. 2501-2508. This paper describes the design and development of a modular UHV testing system for testing a wide variety of loads. The components of the system are described with respect to the following considerations: reliability, portability, extension at a later date, and the ability to perform a wide range of tests. The approach uses a unique system of cascadable transformers and reactors employing a novel electrical and mechanical design. The result of this development is a test system that meets a variety of testing requirements. (Engineering Index abstract, from Compendex)

[1983] TF-020
REQUIREMENTS AND PERFORMANCE OF THE NEW CESI HIGH POWER FACILITIES. E. Brasca, A.C. Dominioni, S. Rovelli, A.R. Tiramani. IEEE Transactions, PAS, vol. 102, no. 7, July 1983, pp. 2224-2230. The latest in high power laboratories is discussed, focusing on the future of HV circuit breaker testing, and of synthetic circuits, the role of which has become fundamental in the recent years. Furthermore, the need for a substantial increase in quality and efficiency of direct testing is summarized and a proposal for automation and digital data acquisition is put forward. A description from the Centro Elettrotecnico Sperimentale Italiano (CESI) in Milan, Italy, is given of the new High Power Laboratory GPS, recently commissioned, the design of which was based on these criteria. As a result, higher power is available, particularly for UHV circuit breaker testing. A new rotating machine supplies short circuit current at any frequency from approximately 16 to 65 Hz, thus covering 50 and 60 Hz practices. (Engineering Index abstract, from Compendex)

[1983] TF-021
UHV CLASS TEST FACILITIES IN JAPAN. T. Harada, T. Kawamura, M. Honda, T. Watanabe, K. Naito. (Abstract, source unavailable)

[1984] TF-022
TESTING OF A 1100 kV, 3 TO 9 GVA UNDERGROUND TRANSMISSION SYSTEM. F. Farneti, P. Menesatti, E. Dotti, G. Luoni. IEEE winter meeting, 1984, paper 190-5. In the framework of the 1000 kV Project, agreement was reached between National Electric Energy Agency of Italy (ENEL) and Societa Cavi Pirelli to carry out an extensive experimentation on an assembly including a 1100 kV self-contained, oil-filled cable and accessories, with a view to assess the reliability of such system intended for connections in power stations as well as for feeding areas with particular environmental constraints. To this end, a testing plant was assembled at Suvereto Experimental Station and tests were started in early 1981. The paper gives the characteristics of the cable and accessories and describes the testing facilities set up for the purpose. After a brief mention of the test program, results are presented on the main tests carried out so far. (Abstract from paper)

[1984] TF-023
METAL-ENCLOSED 1000 kV TESTING STATION FOR ROUTINE TESTING OF SF6-INSULATED SWITCHGEAR. L. Fischer, L. Hashoff, G. Luxa. Siemens Power Engineering, vol. 6, no. 4, July-Aug. 1984, pp. 204-208. A new completely metal-enclosed HV testing station for SF6-insulated switchgear has been put into service in the Siemens Schaltwerk in Berlin. It consists of a testing transformer for a maximum power frequency test voltage of 1000 kV plus protective and measuring equipment-including that for partial-discharge measurements-and a largely automatic SF6 gas supply system. (IEE abstract, from Inspec)

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