



NAME : R. Diaz  
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Role of experienced members regarding the education in Electric Power Engineering of incoming members of CIGRE

R.Diaz

High-Voltage and Power Transmission Institute, National University of Tucuman, Argentina

Introduction

This contribution shows an overview of Electric Power Engineering Education in Argentina and the personal experience about the role of Cigre members.

As shown by the EPEE panels in 2004 and 2006, Electric Power Engineering seems a downsizing profession in many developed and developing western countries, just when electric power consumption grows firmly again. Diverse reasons led to reduce the number of EPE graduates and this situation was discussed in the previous EPEE panels. However, in order to have a positive appreciation of the situation, it would appear that EPE derives from the Electrical Engineering tree which is still a vigorous and dynamic profession with many new arms. In fact, since the 1960s decade the Electrical Engineering education programs (originally power and radio-communications) derived in several new programs and degrees: Electric Power Eng., Electronics Eng., Electromechanical Eng., Telecommunication Eng., Biomedical Eng., Computational Eng., Robotic Eng., and so. Actually the electrical industry employs competences of several engineering specialities associated with electricity.

EPE in Argentina

Argentina is a developing country with a medium GDP (Gross Domestic Product) per capita and 40 millions of inhabitants. The EPE is taught in 27 faculties which graduated about 125 students last year. This number represents only 5% of the total number of graduates in engineering (excepting computational engineering and, of course, agronomical engineering), and can be compared with 385 graduates in Electronics Engineering and 140 in Electromechanical Engineering at the same time. Only 60% of specific vacancies in manufacturers, industries and utilities are filled with Electric Power Engineers, and a similar situation exists for academic staffs.

The engineering programs were updated in the last decade in agreement with the requirements of the education law nr. 24521/95, fulfilling the mandatory contents approved in 2001 by the National Education Ministry (Res.nr. 1232). The educational programs are periodically supervised and accredited by a federal agency (CONEAU), and the engineering programs must include a minimum set of mandatory contents in 3750 hs of courses. In general, EPE students follow out about 4000 to 4250 hs of systematic training and instruction. An education credit system is still under analysis.

Structure of EPE programs

The mandatory contents for the Electric Power Engineering programs approved by the Argentinean Education Ministry are the following:

*Basic Sciences courses:*

Mathematics: Linear algebraic equations and methods, analytical geometry, differential and integral multivariable calculation, differential equations, numerical calculus, advanced mathematical analysis, statistics and probability.

Physics and chemical: Static and kinetics in mechanics; electricity, magnetism, electromagnetism; optic, waves; thermometry and calorimetry; structure of materials, chemical elements, chemical equilibrium and kinetics.

Additional courses: Drawing and representation systems; computational tools.

*Basic Technology courses:* electrical circuits, electrical measurements, analogue and digital electronic circuits, microprocessors, electrical and mechanical machines, control theory.

*Applied Technology courses:* generation and transmission of electric power, electromechanical energy conversion, industrial and power electronics, electrical installation and lighting, utility systems, principles on power system analysis and protection.

*Complementary courses:* economic theory, organization theory, project management, legislation, business and investment analysis, environmental management, professional safety, foreign language.

An additional obligatory skill is a professional training in enterprise (200 hs. minimum). Several national universities include the preparation of an engineering thesis as additional requirement.

Every faculty can include advanced subjects in supplementary courses of about 200 to 400 hs, like power systems stability, insulation coordination, power quality, high-voltages techniques, lightning protection, electro-magnetic compatibility.

There are several pos-graduate programs in the country, but the number of graduate students is low because the long actual duration of the educational programs and a high request of employment in the uncovered labour market.

The efficiency of the engineering educational system must be improved, because 50% of graduates need between 7 and 8 years to complete the first degree (for a theoretical duration of 5 years) and the rate (graduates/admitted students) is only between 10 and 15%.

One half of EPE graduates obtain the degree at 26 years of age or more, which explains partially the low frequentation of our pos graduate programs.

#### Role of experienced Cigre members

In this context, the role of experienced Cigre members can help to support the EPE education creating links between industry and academic world, suggesting modifications in programs and courses, and proposing subjects for research, at level of engineering, master or doctorate thesis.

From a personal point of view, actions are possible in several ways, for example introducing learning topics in EPE programs and proposing academic research subjects linked with current problems discussed in Working Groups of Cigre.

The connection between teaching experience and the knowledge of emerging technologies in electric power systems helps to improve methodologies and educational programs attracting the best students. Other action is the introduction of interesting subjects for thesis and student projects, linking basic academic research with Cigre issues.

As a personal experience, three cases can be mentioned where academic research was linked with Cigre subjects, including participation of EPE advanced students and young engineers:

\* Physics of discharges: this academic research subject was linked with revision of standards IEC 60052 and IEC 60060, by using basic research results about corona inception in air and improving methods for reducing sphere-gaps breakdown dispersion.

Résumé: The corona voltage and their conventional deviation for impulse voltages in point-plan air gaps can be reduced introducing artificial negative ions or moisture. The atmospheric air contains several types of ions, which were identified and measured with homemade ion counters. The traditional device for measuring peak high-voltages is the sphere-gap, as recommended by IEC 60052. Sphere-gaps basically produce uniform or quasi-uniform fields and corona inception leads to the development of an electron avalanche which dimension is sufficient for creating a streamer discharge and breakdown. Improvements in the use of sphere-gaps tables have been introduced by the new standard (Ed.3th, 2002) assuring a limit for disruptive voltage uncertainties, i.e. reducing the conventional deviation for the disruptive discharge voltage. The standard indicates that the required deviation shall be attained (1% for ac and LI, and 1.5% for SI). Far ultraviolet irradiation is recommended but another way was investigated by using extra irradiation of the gap with a dc corona source of negative polarity. This source furnishes

free electrons in the gap between spheres at the moment of application of voltages. Work was made with students in order to develop and verify this procedure.

Some IWD of Cigre concerning this subject:

"About the Use of an Ion Source for Sphere-Gaps". CIGRE WG 33.03, IWD 47, Winchester, England, 1996.

"Contribution to the revision of IEC Publication 52". CIGRE WG33.03 IWD 36, Weggis-Switzerland, 1999.

"Detection of impulse corona in hv circuits by ion measurement". CIGRE WG 33.03, IWD 45, Dresden, Germany, 2000.

"Humidity-ion density relationships". CIGRE WGD1.33 "High-voltage testing and measuring technique", IWD 42, Arnhem, Holland, 2003.

"The influence of ions on the sphere-gaps discharge". CIGRE WGD1.33, IWD 43, Arnhem, Holland, 2003.

"Influence of the impulse voltage tolerance on the probability to pass a withstand voltage test (IEC60060-1)", CIGRE D1.33, Larnaca, Cyprus, 2006.

Some examples of thesis, linked to this subject, developed in the last years at the High-Voltage and Power Transmission Institute of the National University of Tucuman (IATTE-UNT):

- "The cathode effect on the negative corona inception".

- "Design and manufacture of a Picoammeter for Gerdien counters".

- "Design and manufacture of an impulse current generator for grounding systems evaluation".

\* Simulation of electric power devices and systems: this is a very useful subject because students can integrate previous technological knowledge with modeling techniques. Attention should be paid to avoid only simulations without experimental feedback, the experimental verification techniques in laboratory are very important for the best learning process.

Résumé: Metal-oxide surge arresters have dynamic characteristics that are significant for over voltage coordination studies involving fast front surges. Several models with acceptable accuracy have been proposed to simulate this frequency-dependent behavior. Difficulties arisen in the calculation and adjustment of the model parameters: in some cases iterative procedures were required, in others the necessary data are not reported on manufacturers' datasheets. A simplified model for zinc oxide surge arresters has already been developed, on the basis of the frequency-dependent model recommended by the IEEE WG.3.4.11. A straightforward approach for the generation of the model parameters, from published manufacturer's data, was developed. The model was verified in laboratory for several medium voltage arresters from different manufacturers. The simulations were performed with the Alternative Transient Program (ATP) and the results were compared with both the data reported on the manufacturer's catalogue and experimental data acquired in the high-voltage laboratory with an h-v impulse generator used as an impulse current generator for standard tests on metal-oxide surge arresters.

Some documents concerning this subject:

"High-current tests with an high-voltage generator". CIGRE WG 33.03, IWD 36, Joensuu, Finland, 1998.

"Metal-oxide arrester model for fast transient simulations", International Conference on Power System Transients, Vol. 1, 2001, Brazil.

"Simulations and tests on surge arresters in high voltage laboratory", International Conference on Power System Transients, Vol. 1, 2001, Brazil.

"A case of protection with line surge arresters". B2.01, XII Encuentro Iberoamericano de CIGRE (ERIAC), Foc do Iguacu, 2007.

Some examples of engineering thesis, linked to this Cigre subject, developed in the last years at the IATTE-UNT:

- "Simulation with ATP-EMTP of a high-voltage generator plant (1000 kV/25 kJ)".

- “Metal-oxide arrester model for fast transient simulations by ATP-EMTP”.
- “Simulation of EM transients in 145 kV substations”.
- “A model of the North-west Argentinean power electric network (145 kV) for EM transient simulations”.

\* Calibration of high-voltage measuring systems: This subject gives a large number of applied and theoretical research subjects developed in academic h-v laboratories, which allow effective training to EPE students and graduates in metrological skills and h-v techniques.

Résumé: IEC standard 60060-2, High voltage testing techniques, recommends several methods for calibration of high voltage measuring systems: calculation from measured parameters, low-voltage calibrators and high-voltage comparison. To compare the lightning impulse measurement capabilities of high voltage laboratories, a lightning impulse voltage measuring system was circulated around the world. Twenty-six laboratories compared their impulse voltage measuring system at voltage levels between 80 and 400 kV with the circulating reference system coordinated by Helsinki University of Technology. A local impulse measuring system was designed, manufactured and calibrated in our laboratory. EPE students were introduced to calibration techniques; design and manufacture of low-voltage impulse calibrators were proposed as engineering thesis.

Some IWD of Cigre concerning this subject:

"Low-Voltage Calibration - Experience of Use". CIGRE WG 33.03 IWD 39, Lake George, USA, 1997.

"Use of Low Voltage Calibrators in Impulse Voltage Measurement". Electra nr. 189, 2000, France.

"Progress of a worldwide comparison of LI measuring systems-round2". CIGRE WG 33.03, Arnhem, Holland, 2003.

Some examples of engineering thesis, linked to this subject, developed in the last years at the IATTE-UNT:

- “Data acquisition and processing for GPIB instrumentation in a h-v lab”.
- “Design of a shielding cage for electromagnetic interference suppression in high-voltage laboratory”.
- “Design and manufacture of a low-voltage calibrator for LI and SI”
- “Design and test of a portable lightning impulse voltage measuring system”

### Remarks

The present and future times seem favourable for Electric Power Engineering, but its development is threatened by the insufficient number of professionals. In order to avoid serious troubles, electrical industry, NGO, governments and educational institutions must coordinate immediate actions to recruit EPE students:

- Improving the “marketing” of EPE in colleges and schools.
- Financing participation of EPE students in national and regional events.
- Introducing prizes for students and junior engineers for contributions to congress and events.
- Financing EPE thesis.
- Supporting grant systems for EPE students since the first year of course. For example, a scholarships educational program has been granted for a small number of engineering specialities by an Argentine foundation ([www.robtorocca.org](http://www.robtorocca.org)) financed by a multinational engineering and construction business, in several countries (Argentina, Brazil, Colombia, China, Italy, Japan, Mexico, Rumania, Venezuela).