PRESENT AND PROSPECTIVE STATUS OF REGULAR COURSES HELD IN SÃO PAULO FOR TRAINING IN NUCLEAR ENGINEERING

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Since its foundation, in 1956, the Instituto de Energia Atômica has been developing courses, different in purpose and ranging from the technical to the scientific level, for the training of specialists capable of participating in the research and development work required for the furtherance of peaceful applications of nuclear energy in Brazil. From its very inception, the Institute was intended to have a research reactor, which obviously represents a unique tool in nuclear education, apart from its role in specific fields of scientific activities.

Concerning Nuclear Science and Engineering, three courses were delivered at the IEA, prior to 1960, with the principal objective of orienting along a specific nuclear line, engineers and physicist who were to be incorporated into the staff of the Institute, in order to collaborate there with senior members. The syllabus of those courses were centered on pertinent aspects of experimental nuclear physics, reactor physics, basic radiochemistry, health physics and nuclear instrumentation; it was understood that such training was to be continued and completed at a second stage, in the laboratories of the Institute. On the whole, this solution brought about good results, although it was considered a temporary solution.

On the other hand, the School of Engineering pertaining to the University of São Paulo, underwent, in 1954, a restructuring of its curricula, and since then, has been contemplating the feasibility of including, among other tasks, the teaching of some branches of applied nuclear sciences. In accordance with approved schedules, the plan aimed at supplementing the education of graduate engineers, trained in various specialities (mechanical, elec-

trical, metallurgical engineering, etc, with the theoretical and experimental knowledge that would enable them to work in the wide field of atomic energy. It was clear to those responsible for the restructuring that the so-called Nuclear Science and Engineering reached over into several areas of both the fundamental sciences and different branches of traditional engineering.

In 1960, the Escola Politécnica (School of Engineering), and the IEA decided to combine efforts, under the aegis of the Brazilian Nuclear Energy Commission, in order to conduct specialization courses in Nuclear Engineering, destined for engineers, physicists and mathematicians who graduated from University-level Faculties or Schools. This new course lasts one year, having been developed in 1960-61 and in 1962; its third cycle is at present under way for 1963.

The curriculum of the course is divided into basic training and special training, the duration of the latter being approximately double to that of the first period.

Due to given circumstances, it has not been possible in all three repeated cycles to maintain the same individual programmes for all subject matters integrated in the proposed curriculum. But the backbone of the structure has remained unchanged so far; different views exist as to the depth of the programmes as well as in the balance of the diverse parts of each teaching programme.

The aim envisaged for the basic period of the curriculum, is to suplement the education of the participant engineers with more profound studies on the constitution of matter and its microscopic properties (interaction between radiation and particles, natural and artificial desintegration of nuclei, fission, theory of nuclear reactions), and, likewise, to supplement the education of physicists and mathematicians with studies on thermodynamic cycles and more data on heat transfer. For all students, a more specific knowledge of nuclear instrumentation and techniques of nuclear measurements was approached, the aforementioned preceded by a general review on Electronics, affording participants a better understanding of the functioning of electronic equipment, and a more accurate interpretation of actual observations.

The special period of the curriculum is to comprise Reactor Physics, Reactor Materials (Technology and Chemistry), Health Physics and Reactor Engineering, as also a number of lectures on the production and application of radioisotopes.

Reactor Physics: the programme includes basic theories, application to the calculation of heterogeneous reactors, reactor parameters, dynamic behaviour and control, followed by notions on the theory of transport, the theory of perturbation and applications. Lastly, the study on various types of reactors, nuclear cycles and breeders.

The study of nuclear materials is based on two points of view, viz., technological and chemical. It includes the properties of materials utilized in reactors, techniques for obtaining these materials, including notions on nuclear metallurgy, destructive and non-destructive tests of structural components, radiation damage behaviour. It is supplemented by: chemical study of nuclear materials; production and purity control of uranium, thorium and their compounds; chemistry of fission fragments and of other nuclear materials, viz. graphite, berrylium, zirconium, etc. Treatment and utilization of wastes. Notions on isotopic separation, treatment of irradiated fuels, production of heavy water.

Reactor engineering comprises: special problems relative to reactor heat transfer; thermodynamic cycles and their application to reactor; real structure, shieldings and effective reactor operation; critical analyses and comparison of various types of reactors, with emphasis on power reactors. Optimization and Design studies. Nuclear fuel economy, nuclear power stations and problems of integrations within existing networks. Reactor Engineering teaching is one of the chapters that has changed considerably within the three cycles of the course as already mentioned.

Health Physics is taught objectively. Starting with biological effects of radiation, it follows on with studies on dosimetry and discussions on the cares demanded in tasks dealing with readioactive materials or in areas subjected to radiations.

Experience gathered from previous courses justifies the following comments:

Some confusion still exists with regard to the precise meaning of the term "nuclear engineer". First of all it is to be borne in mind that the application of the word "engineer" in Brazil, is more restricted than in the English language (always meaning here a professional graduated from a university, following five or even six years of higher grade studies. Thus, many people are prone to believe that nuclear engineer is a term defining an engineer having specialized in the "nuclear energy" area of engineering, thereby comparing nuclear engineer with civil engineer, mechanical engineer, electrical engineer, etc. The Polytechnic School, when confering diplomas for completion of studies, does not confer the degree of "nuclear engineer" but declares that the bearer (Mr. M. or N.) concluded a "specialization course in nuclear engineering".

In Brazil, the term "engineer" can only be applied to persons who have concluded one of the traditional "engineering" courses, there being a law regulating the engineering profession dating back to 1933, i.e. before the appearance of "Nuclear Science and Engineering". Thus, even those engineers (civil, mechanical et al) having concluded regular courses in "nuclear engineering", do not appear to have the right of using the degree of "nuclear engineers".

The point has been amply discussed within engineering circles but no final decision has been made as yet. On the other hand, outside the profession, opinions are held by some that each and every person having done a University-level engineering course, could be called a "nuclear engineer".

The general public imagines that because of the existence of civil engineering and civil engineer, mechanical engineering and mechanical engineer, etc., therefore nuclear engineering and nuclear engineer also exist.

It might be opportune for a new term coined to designate all professionals with a university level degree (engineers, physicists,

mathematicians, chemists et al), having had specialized training in some or various areas of Nuclear Science and Engineering. If, for instance, such a coined term were "atomenergist" or "nuclear energist" we would be in a position to speak of an "atomenergist scientist" or of a "nuclear energist engineer".

In Brazil, it would also seem appropriate to provide a wider selection or combination of curricula on nuclear science and technology, with standard curricula of engineering or science. In most cases of specialists required for research and development work, as also for a number of scientific or technical tasks in the nuclear field, the best solution might be to furnish a general coverage of the phenomena related to the release of atomic energy and a thorough training in the special line concerned.

The necessity also exists for courses intended for engineering students or graduate engineers who wish to be acquainted with atomic energy, mainly nuclear power, without departing from their standard line in engineering. In this case there would be no use for detailed refinements. A broad knowledge of the phenomena and of existing types of reactors would suffice to allow for these engineers becoming capable of working in a nuclear area, while continuing to be identified with one standard branch of engineering.

Such different approaches to nuclear education are very likely to be carried forward in future regular courses, to be held at the IEA, in cooperation with the Engineering School and possibly other institutions of the University of São Paulo. A project is under way to examine the problem on a larger, national scale.