ADVISORY GROUP MEETING ON EDUCATION AND TRAINING IN NUCLEAR SAFETY

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1. INTRODUCTION

The uncertainties about the future of nuclear power in many countries, the ageing of the existing work force, and the consequential lack of interest of new professionals to engage in the nuclear field is a major current international concern. The situation is even of greater concern because higher education opportunities in the field of nuclear engineering are greatly reduced, with the elimination of nuclear engineering departments and research reactors in many universities and the loss of nuclear research facilities generally.

The IAEA has statutory functions to “foster the exchange of scientific and technical information” and “encourage the exchange and training of scientists and experts” (Articles III.A.3&4 of the Statute). These are specific mechanisms through which IAEA provides for the application of its safety standards (Article III.A.6 of the Statute).

In September 2000, the General Conference (44)/RES/13 referred to its earlier resolutions and stressed the special importance of education and training in radiation protection, nuclear safety and waste management; and urged the Secretariat to strengthen within available financial resources, its current efforts in this area, and in particular to assist Member States (MS) at regional and national training centres that would arrange for such education and training to be conducted in the relevant official languages of the Agency.

In response to the above referred resolution of the General Conference the IAEA convened from 27-29 March 2001 in Vienna an Advisory Group (AG) to review efforts to date and to advise on the overall strategy, structure, scope and means of implementation of an IAEA Programme of Education and Training in Nuclear Safety.

2. OVERVIEW OF IAEA RELEVANT ACTIVITIES TO DATE

In the area of nuclear safety, training opportunities have been offered by the IAEA to professionals from Member States over the past many years. These activities are an important contribution towards fulfilling the education and training needs of MS. Focus has been in the main areas related to safety of design and operation of nuclear power plants (NPPs) and research reactors (RRs), safety assessment methods and tools, and regulatory control.

Training courses and specialized workshops in the above mentioned areas have been offered in English, French, Russian and Spanish languages, as interregional, regional, and national IAEA activities. Most commonly, training activities are implemented in the frame of Technical Co-operation (TC) Projects and Extrabudgetary Nuclear Safety Programmes (EBP).

An overview of training courses and workshops related to nuclear safety during 1997-2000 is provided in the Background Material made available to the AG. This also provides information on other training courses and workshops organized by the IAEA in the frame of its Nuclear Power Engineering activities in 2000.

A nine-week (later condensed to six weeks at the request of the recipient MS) Basic Professional Training Course on Nuclear Safety was developed and offered for the first time at the end of 1999, in English, in Saclay, France, in co-operation with Institut National des Sciences et Techniques Nucleaires/Commissariat a l’Energie Atomique (INSTN/CEA). A standard
syllabus containing 22 modules and a detailed guideline for the lectures were developed. A textbook of some 700 pages was drafted for use in the course. The course was attended by NPP operators, regulators and professionals from technical support organizations mostly from countries in Europe.

A follow-up of the course impact on the professional development and performance of the course participants was carried out by the IAEA and results indicate that the knowledge acquired had an important impact on their technical competence and quality of work.

In 2000, the course was offered in Spanish, in Brazil to Latin American countries and, in English, as a national training course in Romania, with six and four weeks duration, respectively.

In 2001, it is being offered at Argonne National Laboratory in the USA for participants from Asian countries and in Saclay, France for participants from Europe, both with a six-week duration. An improved version of the textbook of some 900 pages was used in the Saclay course.

Since 1980 the IAEA supports a six-month post-graduate course on Radiological Protection and Nuclear Safety organized annually by Argentina in the country. The last two months of the course are devoted to Nuclear Safety topics.

On the more specialized training, a two-week course on Regulatory Control of NPPs has been organized seven times in Europe: Slovak Republic, Finland, Germany (three times), Czech Republic, UK, and twice in Asia: in the Republic of Korea and Indonesia during the period 1994-2000. A textbook of some 300 pages has been drafted for use in the course.

Two other specialized two-week courses are offered in the areas of Safety Assessment of NPPs and Operational Safety. The two-week Safety Assessment course was given for the first time in June 2000 in Helsinki in co-operation with Finnish Radiation and Nuclear Safety Authority (STUK) and Technical Research Centre of Finland (VTT). The purpose of the course is to give a broad overview on safety assessment, including the use of deterministic and probabilistic safety analysis. A course on Operational Safety and Safety Management was offered in 2000 in Karlsruhe, Germany in the form of a workshop. Textbooks for the latter two courses need to be developed.

Other courses are being offered to provide specific expert knowledge, among them is a three-week course on Advanced PSA Modelling Techniques offered in 1999 in Madrid, Spain.

The syllabi of the relevant IAEA training courses and workshops in nuclear safety are included in the Background Material to the AG.

The development of syllabus has been based on the current safety issues considered worldwide and specific insights from the IAEA’s long experience in the provision of safety services.
3. INTEGRATED STRATEGY FOR EDUCATION AND TRAINING IN NUCLEAR SAFETY

3.1. STRATEGY

As a first step for the development of a Programme of Education and Training, a strategy is proposed: It recognizes that there is a need for a long term, sustainable programme of Education and Training in Nuclear Safety in MSs and that a gap exists between the Nuclear Safety knowledge required in MS, and the capabilities of IAEA to deliver training. Therefore, complementary to its training courses, the IAEA needs to concentrate its efforts on assisting MS to establish national sustainable education and training programmes that are in line with international safety standards. An essential element of this effort is the development by the IAEA of model type training leading to train the trainers who will ultimately implement the national programmes in a harmonized way.

The strategy is described in terms of a vision, objectives, outputs and activities required to implementation. It can also serve as a basis for education and training in areas other than nuclear safety.

VISION

Adequate nuclear safety infrastructure including a sustainable programme of Education and Training in Nuclear Safety is in place worldwide and safety is ensured in all practices, consistent with the requirements of the IAEA Safety Standards and other relevant nuclear safety standards.

OBJECTIVES

1. A “Sustainable Education and Training System” should be in place in Member States to develop and maintain competence in nuclear safety, consistent with IAEA safety standards and best practices.

2. An “Education and Training Support Programme” should be further developed by the IAEA in co-operation with Member States, and as appropriate, other international organizations, to extend and augment the existing IAEA training programme and support the above objective.

OUTPUTS

1. A Training Support Programme in nuclear safety, including a standardized and harmonized approach for training developed by the IAEA and in use by Member States.

2. National and regional training centres, established to support sustainable national nuclear safety infrastructures.

3. Training material for use by lecturers and students developed by the IAEA in English for the Basic Professional educational course and the main specialized courses. Member States commitment to translate material to other languages.

ACTIVITIES
The main activities to reach the objectives stated above include:

• Assist Member States in identifying their needs in education and training support;
• define appropriate training requirements to achieve specific nuclear safety competency;
• develop standards and other safety related documents on education and training;
• develop standardized training material;
• support the establishment or further development of national training centres for the provision of regional/national education and training programmes;
• develop exemplary train the trainers programmes;
• exchange information through meetings to harmonize and facilitate co-operation;
• perform quality assessments and peer reviews of regional/national programmes, courses, use of standardized material, to assure adherence to the IAEA Safety Standards; and
• develop and support the use of distance learning training programmes.

3.2. PROPOSED FRAMEWORK

A systematic approach is proposed to support planning and implementation of IAEA activities related to training in nuclear safety. The approach should consider:

• the needs of Member States;
• the wide experience gained by the IAEA to date;
• the IAEA safety standards and current trends in nuclear safety.

The programme calls for a double track approach: (a) focusing on IAEA’s exemplary training for basic and specialized knowledge aimed at professional staff and for training the trainers; (b) the commitment of Member States to establishing their own sustainable training programmes in line with (a) above.

The framework proposed for the IAEA Education and Training Programme in Nuclear Safety is shown in Fig. 1. The axes of the figure show the areas of competency on which training is to be focused (horizontal) and the level of detail to be pursued by the training (vertical). Also indicated on the horizontal axis are the target groups to which training in a particular area should be primarily directed.

The areas of competency are identified according to the structure of the IAEA Safety Standards to emphasize the fact that all the training provided by the IAEA is based on its own standards and recognized international practices. The same approach is to be adopted by MSs providing nuclear safety training.

At the level of basic knowledge, training is intended to provide a broad overview of nuclear safety concepts and their application to NPP and RR design and operation. Its nature and scope are primarily oriented to junior professionals recently involved in nuclear safety related activities. It is also appropriate for some highly specialized professionals who lack a broader view of nuclear safety. The Basic Professional Training Course described earlier in section 2 is the main course offered at this level. This course in its form and content is unique and fulfills a recognized gap in the education and training of nuclear safety worldwide.
Recent experience indicates the need to provide some academic education in fundamentals of nuclear engineering, including basic topics such as reactor physics and thermal hydraulics. This training is essential to those engaged in the nuclear safety field and is increasingly difficult to obtain due to the phasing out of nuclear engineering programmes in many universities worldwide. The use of distance learning tools for self-study is attractive and work is already underway at the IAEA. This topic is further discussed in section 4.

At the level of specialized knowledge, standard training courses are offered on regulatory control, safety assessment, and operational safety of NPPs and RRs. Target groups are technical staff of the regulatory bodies, technical support organizations, NPP operators, RR operators and users, scientific personnel from research institutes, and educators. The syllabus of such courses is provided in a separate document. Textbooks for some of these courses have been drafted and need to be further developed.

At a more specific expert level, workshops are generally preferred as they provide more appropriate conditions for an effective exchange of information and experience among practitioners. Some topical courses and workshops at this level are also indicated in Fig. 1.

The framework for education and training is complemented by opportunities for practical on-the-job training awarded as Scientific Visits and Fellowships by the IAEA on a case by case basis. This form of training, normally away from the home country, depends on acceptance by the host country and is considered in cases where the other training opportunities have been exhausted.

A complementary and highly effective form of delivering training and exchange of experience among practitioners is that of offering workshops in the frame of the IAEA safety services. This approach has been particularly used in connection to operational safety services in the areas of safety management and safety culture. Training delivered in the frame of IAEA safety services is of immediate use for NPPs to perform self-assessment. Currently, training courses for operational safety are an integral part of the operational safety services such as the Operational Safety Review Team (OSART) and associated seminars and workshops.
### Areas of competency
- Regulatory control
- Siting & Design of NPPs
- Operation of NPPs
- Research Reactors Design, Operation & Utilization
- Non-Reactor Fuel Cycle Facilities

### Primary audience
- Regulatory body staff
- Technical Support Organizations
- Operators and Utility Staff
- Research organizations and educators
- Regulatory Body Staff, Facility Operators and Technical Support Organizations

### Basic knowledge (standard training courses)
- Basic Professional Training Course on Nuclear Safety
- Fundamentals of Nuclear Engineering

### Specialized knowledge (standard training courses)
- Regulatory Control of NPPs
- Safety Assessment of NPPs
- Operational Safety of NPPs*
- Safety of Research Reactors

### Specific expert knowledge (examples of tailored topical courses or workshops)
- Authorization Process
- Review and Assessment
- Inspection and Enforcement
- Development of Regulations and Guides
- Regulatory Effectiveness
- Accident analysis methods
- Probabilistic safety assessment
- Accident management
- Ageing management
- Safety assessment of modifications
- Safety culture and management of safety NPP operator regulator interface
- Operational experiences and feedback
- Operational practices
- Reg. aspects and safety documentation
- Safety analysis
- Safety in operation and utilization
- Management of ageing
- Safe shutdown and decommissioning

### On the job training, Practical experience
- Scientific Visits, Fellowships, observers in IAEA safety missions

*Currently, training courses for operational safety are an integral part of the operational safety services and associated seminars and workshops.

**FIG. 1. Framework for Education and Training in Nuclear Safety**
4. IMPLEMENTATION STEPS

In line with the strategy proposed in section 3, the following actions are required:

4.1. IDENTIFICATION OF NEEDS OF MS

The IAEA has developed, in consultation with MS receiving IAEA assistance, Country Nuclear Safety Profiles (CNSPs). These documents should be further expanded to include relevant information on the national strengths and limitations of nuclear safety education and training. The systematic evaluation of CNSP can be an effective tool for the evaluation of MS needs and for the development of national programmes of education and training in nuclear safety.

The evaluation should be supported by appropriate requirements and guidelines which need to be developed by the IAEA based on its relevant nuclear safety standards.

4.2. PREPARATION OF COURSE MATERIAL

Standard training material needs to be prepared. This material includes a textbook which should serve as a reference for all topics included in the course. Examples of this type of material are the draft textbooks already prepared for the Basic Professional Training Course in Nuclear Safety and the Regulatory Control. This material needs to be further enhanced, restructured and edited. Similar textbooks need to be developed for the other courses in the category of specialized training.

Complementary to the textbooks, a standard set of viewgraphs on IAEA practices should be prepared and made available to lecturers for use in the courses. Lecturers will have the flexibility to complement these viewgraphs with additional material of their own to reflect their own perspectives, new developments, and/or national experience. Relevant IAEA and INSAG publications should also be made available to participants in the training events.

In the future, both the textbooks and the viewgraphs will need to be translated into the languages in which the courses are offered. Of utmost importance is to ensure the high quality of the technical and visual content of all the material prepared for training and to keep it up to date and harmonized according to IAEA safety standards.

The textbook should be structured in a way which will facilitate its use in a modular form. Each chapter (module) should provide both a general and a more specialized parts:

*General part*

(1) an overview of relevant IAEA safety standards;
(2) associated safety methodology and technology;
(3) specific reactor type technology and national practices; and
(4) exercises and/or case studies for classroom discussions.

National practices are to be systematically added to the modules as new lecturers from different countries are recruited each time the course is offered.

4.3. NATIONAL AND REGIONAL TRAINING CENTRES

As a general practice, basic and specialized training courses should be offered according to updated assessment of the needs of Member States. Topical courses and workshops in the category of specific expert knowledge need to be considered on a case by case basis, particularly if offered at national rather than at regional level.

Since the seventies, Member States have consistently supported IAEA training activities in the area of Nuclear Safety. Regional and National Training Centres in several countries have periodically hosted IAEA training events.

Such training centres will need to play an even greater role in the future implementation of the proposed training programmes. This role includes the provision of facilities, national lecturers and assistance for the preparation of the textbooks and other training material.

The feasibility and need to establish national and new regional training centres needs to be also evaluated. Regional training centres should provide training to trainees from different countries in the region, in the language mainly spoken in the region. An important aspect of a regional training centre is the exchange of information and experience among countries in a given region, cultural aspects taken into consideration.

To date, training activities have been offered by the IAEA mostly in the frame of Technical Co-operation (TC) projects and EBPs. This situation is assumed to remain and to be further supported by EBP funds earmarked for the development of the required standardized training material.

4.4. TRAIN THE TRAINERS

Qualified trainers are essential for the sustainability of national education and training programmes. The IAEA can provide, in addition to the training courses, assistance to prepare trainers both in subject and methodological matters as a means to ensure the multiplicative effect of education and training. The selection of participants for IAEA training events should bear this in mind. This includes assistance to organize training courses based on IAEA’s standard syllabi for the various courses, preparation of exam questions, exercises and case studies for classroom discussion. Guidelines for the lecturers to be recruited should be developed by the IAEA in close co-operation with the national counterparts from the host country.
The assistance provided by the IAEA should augment its programme of training in subject matter with specific training in the methodology to be used in the courses for local course managers.

4.5. DISTANCE LEARNING

Distance learning is a training method which may be an effective alternative to classroom based training. It can be provided for all categories of persons and is particularly appropriate for people who live far from training centres or have insufficient time or funds to attend classroom based training. It may also be an effective use of training resources where only small numbers of people need training.

A typical distance learning package consists of a modular set of course notes, study guides and associated exercises based on specific topics from a syllabus. Participants complete the package in their place of work or at home. The training includes the completion of assessment tasks (e.g., written examinations, research assignments, problem solving exercises), which are then forwarded to a supervisor or tutor for marking and feedback. Distance learning involves a residential programme designed to reinforce the course material and to provide practical work and technical visits. The residential programme may be relatively brief, but it provides sufficient time for the participants to acquire the needed skills, problem solving methods, or other practical experiences. The role of the supervisor is important to the success of distance learning and frequent interactions between the participants and the supervisor may be necessary.

This method of training is an effective use of resources and permits the participants to study at their own pace. However the success of the training depends on the self-motivation of the student to complete the work with the minimum of direct supervision.

With the increased availability of personal computers around the world, many workers now have access to a computer in the workplace. This has stimulated the development of computer based training (CBT) packages consisting of interactive training modules with question and answer sections. The selection of the CBT package will depend on the learning objectives planned for the training. Advice to assist with selection may be available from national authorities.

Under contract by the Agency, the University of Illinois, USA, prepared a set of CD-ROMs with pre-recorded lectures in reactor physics and thermal hydraulics. The material is being used for self-study with homework exercises submitted to the University, reviewed, and returned electronically, monitored by the IAEA, to prepare a group of some 18 professionals from Asia who will participate in a series of training workshops on accident analysis in 2001-2002. The training is in the frame of the EBP on the Safety of Nuclear Installations in the South East Asia, Pacific and Far East Countries.
A tutorial on Fundamental Safety Principles has been developed and is available from the IAEA’s Nuclear Safety internet site (NUSAFE) at http://www.iaea.org/ns/nusafe/index.html.

Modules for self-study in Reactor Physics and Thermal Hydraulics are also under development for future use via internet and distribution in CD-ROMs. The text for these modules are based on material made available to the IAEA by Argentina and Brazil respectively.

The usefulness of this material to MS should be evaluated by the IAEA and insights should be taken into account for developing further modules.

5. ESTABLISHMENT OF SUSTAINABLE NATIONAL TRAINING PROGRAMMES

A most important aspect of the proposed programme is to ensure its sustainability at national level. This requires qualified personnel in Member States to be specifically trained as trainers. IAEA support for such training should include technical subjects, training methodologies and the use of modern teaching tools.

The ultimate goal is for MS to be capable of offering a spectrum of courses and the relevant material prepared in the frame of the IAEA programme. The IAEA should, upon request, provide assistance to MS for the implementation of national training programmes to ensure that the syllabus and technical material that it has delivered is being used as intended.

The IAEA should also provide lecturers for selected subjects for which MS may lack specific knowledge as well as to reflect new safety developments and methodological advances. However, the bulk of training should be provided mainly by national lecturers.

In addition to the existing international training centres, new regional training centres and other training centres in recipient MS, including those with simulators or maintenance training facilities, should be encouraged, supported and qualified to provide national and regional training in Nuclear Safety.

Of utmost importance to ensure sustainable education and training programmes in MS is the government’s commitment to provide the necessary means for the establishment and maintenance of these programmes.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. EDUCATION, TRAINING AND EVALUATION STRATEGY
• The strategy for development and strengthening of the IAEA’s Programme to assist Member States to establish sustainable education and training in nuclear safety (as described in section 3.1) is recommended.

• The Advisory Group noted with appreciation the large effort of the IAEA in the provision of training in nuclear safety and suggests that the IAEA considers the establishment of an Agency wide education and training policy consistent with the above mentioned strategy and its long experience in this field.

• The IAEA should consider the publication of an information pamphlet describing the training and education opportunities and assistance available to Member States in the area of nuclear safety.

• The IAEA is encouraged to continue to evaluate the long-term impact and effectiveness of its training programme. The IAEA should also develop methodology and encourage the Member States receiving training to evaluate the effectiveness of the training and report the results to the Agency.

6.2. FRAMEWORK FOR THE IAEA PROGRAMME

• The framework described in section 3.2 of this report is recommended. It is recognized that training in the area of safety of non-reactor nuclear fuel cycle facilities can only be developed after the IAEA publishes the relevant set of safety standards for such installations.

6.3. SYLLABI OF TRAINING COURSES AND WORKSHOPS

• The syllabi of various training courses and workshops offered by the IAEA to date show consistency with the objective of the courses. It is recommended that the syllabi be periodically revised to ensure that they address the needs of Member States, the emerging safety issues and challenges facing the nuclear industry, and methodological developments.

6.4. TRAINING MATERIAL

• The preparation of modular training material of high quality to support the training courses is essential.

• The textbook material already developed for the Basic Professional Training Course in Nuclear Safety given at Saclay in 1999, and for the course in Regulatory Control of NPPs should be reviewed, revised, and published. Revisions should consider information made available to the IAEA by various lecturers since these courses were first offered.

The textbook material should include core material providing an overview of the IAEA relevant standards, along with basic material on safety technology and
generally accepted safety practices. All information included in the textbook should be in the public domain to allow wide distribution to Member States. A set of viewgraphs should be prepared consistent with the textbook to support lecturers’ presentations. This set of viewgraphs should also be made available to course participants.

- In addition to the core material on IAEA standards and the basic material on safety technology and practices, additional material relating to specific reactor types and national experiences may be included for use as appropriate. In presentation of a course, it is expected that this IAEA-furnished material will be augmented by other material appropriate for the audience or national needs.

- The IAEA should periodically revise and update textbooks and supporting material.

- It is recommended that the IAEA safety standards be made available to MSs in the internet to facilitate their use in the Education and Training Programmes.

- The effort of preparing quality training material should be extended to the other standard training courses at the specialized level namely: Safety Assessment of NPPs and Safety of Research Reactors. The IAEA should also evaluate the need to prepare similar material for an operational safety course.

### 6.5. DISTANCE LEARNING TOOLS

- The use of distance learning tools as a complement or prerequisite of more traditional training in nuclear safety is supported.

- The efforts of the IAEA to produce videos and CD-ROMS for training in basic nuclear safety topics is appreciated and the IAEA is encouraged to pursue the efforts to use modern training tools.

- The IAEA should evaluate the impact and usefulness of the distance learning tools that it develops and make available to Member States.

### 6.6. TRAIN THE TRAINERS

- The role of IAEA in this area should be primarily to enhance the wide dissemination of nuclear safety knowledge at the national level in Member States.

- A pragmatic approach recommended is for the IAEA to assist countries to organize and run national training courses using the syllabus and relevant material prepared by the IAEA. The assistance by the IAEA should augment its programme of training and include training local course managers in the subject matters and methodology to be used in the courses. Guidelines for lecturers should be further developed and made available by the IAEA including training methodology, the required communication skills, preparation of lectures consistent but not necessarily limited to the material provided by the IAEA, organization and material
for discussion sessions and case studies, preparation of course exams and evaluation of course results.

6.7. SUSTAINABILITY OF NATIONAL PROGRAMMES

• The IAEA programme should aim at the sustainability of national training and education programmes.

• The IAEA is encouraged to provide, upon request, advice to Member States to carry out a broad evaluation of national training needs in nuclear safety and to develop and assist in the implementation of the required training. A specific advisory service supported by specific guidelines should be considered by the IAEA as a means to deliver this advice in a comprehensive and consistent way.
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