The Statutory Role of the Greek Atomic Energy Commission on the Occupational Radiological Protection Control System

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ABSTRACT

The Greek Atomic Energy Commission (GAEC) is a decentralized civil service, under the Minister of Development, governed by a Board of Trustees. It is the competent authority, responsible for issues concerning nuclear energy, nuclear technology and radiation protection of the public, workers and environment against the dangers of ionizing and artificially produced non-ionizing radiation.

According to the national legislation, the GAEC is the regulatory authority, responsible for the implementation of radiation protection regulations. Among its responsibilities is the performance of inspections in all radiological and nuclear installations concerning medical, industrial, research and educational applications, as well as the authorization and licensing of the non-medical applications and NORM activities, in order to assure compliance with the radiation protection regulations.

A description of the GAEC's statutory role and the general lines of the methodology followed in order to accomplish its tasks will be presented, focused on occupational radiological protection control and assessments through inspections. The inspectors' qualification, the equipment used, as well as the infrastructure of the supporting laboratories (e.g. individual monitoring, environmental radioactivity control and secondary standard dosimetry laboratories) are also presented.

INTRODUCTION

The Greek Atomic Energy Commission (GAEC) was established by an Act in 1958 as the authority responsible to plan, apply and supervise the necessary measures to protect humans and property against radiation. Nowadays, according to the legislative arrangements of 1987 (1,2), the GAEC is an independent Decentralized Civil Service under the Minister of Development and is the competent authority responsible for matters concerning nuclear energy, nuclear technology and radiological protection against the dangers of ionizing and artificially produced non-ionizing radiation. This paper presents briefly GAEC's responsibilities, and gives the general lines of the methodology followed in order to accomplish its tasks, focused on occupational radiological protection control and assessments through inspections. The inspectors' qualification, the equipment used, as well as the infrastructure of the supporting laboratories are also presented.

GAEC's STATUTORY ROLE and ORGANISATIONAL SCHEME

According to its statutory role (1,2), GAEC is responsible for the:

1. Protection of radiation workers, the general public and the environment against the dangers of ionizing radiation in the fields of nuclear science and technology applied to industry (including NORM activities), agriculture, health, biology and other sciences.
2. Protection of radiation workers and the general public against the dangers of artificially produced non ionizing radiation.
3. Emergency preparedness and implementation of emergency plans to cope with radiation accidents, radiological threats and increased radioactivity levels.
4. Approval of new applications of ionizing radiation.
5. Promotion of the peaceful applications of nuclear technology and nuclear sciences.
6. Education and training on radiation protection matters of radiation workers and the personnel of other organizations and services involved in the national emergency response plan.
7. Information of the public.
8. Introduction of radiation protection regulations and monitoring of the implementation of the regulation.
9. Introduction of safety standards and codes of practice for ionizing radiation installations.

GAEC according to its organizational scheme consists of four Divisions, namely:

1. Division of Regulatory Control (2 departments),
2. Division of Licensing and Inspections (3 departments),
3. Division of Research, Development and Education (2 departments),
4. Division of Administration and Technical Support (3 departments),

as well as three independent offices and one independent laboratory.

RADIATION PROTECTION ACTS and REGULATIONS

The frame law concerning radiation protection came into force in 1974 (3) and establishes the framework for the protection of the public and the goods against the dangers from ionizing radiations regardless of their origin. According to this decree, any application or practice employing ionizing radiation is subject to prior authorization. It also provides the issue of radiation protection regulations in the form of Ministerial Orders.

The first radiation protection regulations were issued in 1978, concerning only medical applications. These Regulations were revised in 1985 and in 1991 (4) when they incorporated two European Council Directives (5,6). These regulations before entering into force were approved by the Commission of the E.U. according to the article 33 of the Euratom Treaty.

The 1991 regulations underwent a major revision in order to be brought into line, with the new EU directives (7,8) which were published in 2001 (9). These regulations cover practically all practices involving the use of ionizing radiation in radiodiagnostic, nuclear medicine and radiotherapy laboratories, laboratories for research, education and training, industrial radiography laboratories, particle accelerator installations, NORM activities, management and disposal of radioactive wastes and transport of radioactive materials. They also provided quality control and quality assurance measurements for all installations producing or detecting ionizing radiation.

LICENSING, INSPECTION and SAFETY EVALUATION

GAEC issues licenses for: (a) the import, export, transport, storage, use and disposal of radioactive materials including fissile materials, (b) research and training applications, (c) the import and use of radiation producing equipment, (d) NORM activities and (e) the non medical applications by the joint decision of the Minister of Development and that of the Minister responsible for the application.

The enforcement of the Radiation Protection Regulations in laboratories utilizing ionizing radiation is accomplished by:

1. Inspections and evaluations of quality assurance programs.
2. Quality control inspections and dosimetry measurements in machines and systems producing, emitting and/or using ionizing radiation, in use or to be imported.
3. Issuing Certificates of Compliance for medical ionizing radiation laboratories.
4. Licensing the industrial, research and educational ionizing radiation laboratories.
5. Evaluation of the structural and shielding design of ionizing radiation laboratories.
6. Evaluation of doses received by exposed workers, due to radiological accidents or abnormal incidents and planned exposures.
7. Keeping the national inventory of all radiation sources, equipment and dose records.
8. Introducing guides concerning radiation protection, quality control and the safe operation of equipment and radiation sources.
9. Licensing of the import, export, possession, use and transport of radioactive materials.

a. Medical Laboratories

The inspectors of the Licensing and Inspection Department of the Licensing and Inspection Division perform:

1. Prior to notification inspections, on a three year basis, in 24 radiotherapy laboratories, where 33 linear accelerators, 14 Co60 systems, 8 HDR or LDR brachytherapy systems, 5 radiotherapy X-ray systems are in operation.
2. Prior to notification inspections, on a five year basis, in 1200 diagnostic radiology laboratories, where approximately 180 CT scanners, 1800 X-ray conventional systems, 220

mammography systems, 200 DPX, 60 interventional diagnostic radiology systems are installed.

3. Prior to notification inspections, on a two year basis, in 180 nuclear medicine laboratories, where approximately 230 gamma cameras and 1 PET/CT operate, 15 wards for the accommodation of patients administered with therapeutic doses of radio-isotopes and 60 RIA laboratories.
4. Without prior to notification to all above laboratories on a random basis or when there is a suspicion for radiation protection regulation violation.

During the inspection, certain operational parameters of the radiation systems are checked according to certain protocols developed by the GAEC; the measurement results are compared to the specified acceptable limits. All radiation protection measures of the laboratory are evaluated in order to assess the radiation protection of the personnel, patient and public. The quality assurance and quality control programs, the personnel dose records, servicing and maintenance of equipment, staff training etc, are evaluated. Dosimetry measurements are performed in order to obtain patient doses.

In case the laboratory conforms to the radiation protection legislation, GAEC issues a certificate of compliance, which is an obligatory document for the licensing of the laboratory by the Ministry of Health.

b. Industrial Laboratories

The inspectors of the Licensing and Inspection Department perform inspections in more than 500 industries / laboratories using ionizing radiation devices and radiation sources every two years. Among them there is one private irradiation facility for sterilization of medical equipment. The radiation protection of workers, the safe use, operation, handling, storage, transport and record keeping of every radiation source and device are checked and evaluated.

c. Laboratories for Research and Education

About 180 laboratories, most of them research institutions and university departments, use ionizing radiation for research and education purposes (radioisotopes, radiation producing equipment, instruments incorporated with radiation sources etc). In these laboratories the inspections are performed in a two year period.
Among these laboratories are a 5 MW swimming pool type reactor for research and isotopes production, an 11 MeV Tandem Accelerator and an isotope production laboratory in the NCSR “Democritos”. Two sub-critical assemblies for research and educational purposes belong in two University laboratories.

d. Scrap Metals

GAEC issues the import license for scrap metals. For that purpose GAEC accepts certain certificates, or performs in situ inspections and measurements.

e. Naturally Occurring Radioactive Materials

The main work activities in Greece which may lead to a significant increase in the exposure of the workers or the public, due to natural radiation are: (a) mines and quarries, (b) thermal spas, (c) phosphate industry, (d) cement production, (e) oil & gas industry, (f) caves and (g) aero-engines repairing workplaces, (f) lignite fired power plants. The identification of these places by GAEC is based on measuring and monitoring the levels of radon concentration and gamma - dose rates (10,11). The following criteria for “work activities” with NORM have been established and included in the radiation protection regulation(9):

1. Work activities where the corresponding dose is less than 1mSv/y or the mean annual radon concentration is less than 400Bq/m^3 (mean annual radon concentration corresponding to 2000 working hours per year) are excluded from further investigation.
2. Areas with work activities where the corresponding effective dose exceeds 1mSv/y but is less that 6mSv/y, or the mean annual radon concentration are between 400Bq/m^3 and 1000Bq/m^3, are characterized as supervised areas. Appropriate measures to optimize the dose approved by GAEC are applied.
3. Areas with work activities where the corresponding effective dose exceeds 6mSv/y but is less than 20mSv/y, or the mean annual radon concentration is between 1000Bq/m^3 and 3000Bq/m^3, are characterized as controlled areas. Special authorization by GAEC is required.

The estimation of doses to the workers is based on measurements performed in situ and at the laboratory. Gamma and alpha spectrometric measurements of collected samples from raw materials, air filters and measurement of radon concentration with track-etched detectors are used at the scenarios relative parameters, in order to estimate the occupational exposure.

Two fertilizer production industries and workplaces where repair of aero-engines constructed by Th-Mg alloy is performed, have been identified and licensed by GAEC, as "work activities" so far. Proper waste management is also required for the specific activities. Each disposal option shall be authorized by GAEC. Moreover, radon levels in specific areas inside the industries are regularly monitored using track-etched detectors.

INFRASTRUCTURE

In order to accomplish these tasks, GAEC has established specialized laboratories unique in the country. The laboratories are accredited by the Hellenic Accreditation Council according to ISO 17025. Moreover, the Secondary Standards Dosimetry Laboratory is a member of the WHO/IAEA SSDL network. All these laboratories participate systematically in European and International intercalibration and intercomparison exercises as well as in research projects. The main purpose and infrastructure of these laboratories is as follows:

1. For performing inspections in all radiation installations in the country, the inspectors are equipped with excellent and up to date sets of equipment, as dosemeters with ionization chambers and solid state detectors, electrometers and different kind of ionization chambers, phantoms (water, solid, tissue equivalent), non invasive kVp meters, timers, portable survey meters for gamma, beta, X and neutron detection and measurements adequate for each application and all necessary accessories.

2. For the individual monitoring of workers of category A and B in Greece, GAEC is equipped with a fully automated TLD system composed by 3 automatic readers, two irradiators, two ovens and more than 35 000 dosemeters (12). Moreover, one manual reader and several dosemeters of different types are used for neutron measurements and measurements for medical purposes. GAEC keeps the National Dose Registry Information System containing dose records for more than 30 years and performs the statistical analysis of dose results. An effort has been made to apply dose constraints to the individual annual doses of exposed workers in the medical sector (13).

3. For the internal dosimetry of workers and of public in case of accidents or other radiological events, GAEC is equipped with a shadow shield Whole Body Counter (CANBERRA) with two detectors (GeLi and NaI). A thyroid uptake counter, dose calculation softwares (IMBA and LUDEP), appropriate sources, phantoms and accessories complete the infrastructure. Moreover, in GAEC's radiochemical laboratory bio-assay analysis are performed.

4. For the environmental radioactivity control and activities related to NORMs, GAEC is equipped with: Two low level gamma spectroscopic systems, one portable XRF system, 14 low level alpha spectroscopic systems. A radioanalytical laboratory fully equipped with instruments for radionuclides isolation for environmental and biological samples. Portable instrumentation for in situ radon measurements and the infrastructure to measure radon with passive techniques. The GAEC's mobile laboratory is equipped with a low level gamma spectroscopic system, a low level total alpha/beta counter, several portable instruments as spectroscopic systems for in-situ radioactivity measurements, gamma and total beta survey instruments. A telemetric system consisting of 24 total gamma dose rate detectors, 4 gamma spectroscopic systems for water measurements and 3 systems for aerosol measurements complete the infrastucture.

5. The Hellenic Ionizing Radiation Calibration Laboratory of GAEC, is a Secondary Standard Dosimetry Laboratory (SSDL) traceable to primary laboratories like BIPM, IAEA, NPL, that provides calibrations, intercomparisons and performance/type tests in radiation laboratories all over the country. It has developed and maintains the national reference dosimetry standards (Gy, Sv, Cb/kg) of ionizing radiation (gamma, X and beta) and performs calibrations of instruments used for measurements of ionizing radiation in terms of Air Kerma, Absorbed

Dose, Individual Dose Equivalent Hp(10) and Hp(0,07), Environmental Dose Equivalent H*(10) and Exposure in the fields of radiotherapy, radiology diagnostics, mammography, radiation protection and individual dosimetry of workers. The major equipment is composed of: Irradiators: therapy Co60 unit 148 TBq (4kCi) -Feb 99), X-ray 225 kVp – HF, STS - OB2 Co60 unit (100 mCi -Feb 99), OB6 Cs137 740 GBq (20 Ci), STS - OB34 Panoramic with 3 Co60 sources (3.7, 25.9 & 37 MBq) & 4 Cs137 sources (7.4, 74, 740, 7400 MBq). X-ray GENERATOR, 150 kVp - 12 pulse connected to diagnostic type X-ray tube Tu anode. Mammography type X-ray tube. Several dosemeters and electrometers complete the laboratories infrastructure.

6. GAEC is responsible for activating the national emergency plan in case of a radiological or nuclear accident or incident. Recently because of GAEC's implication in the preparation of the safety and security measures for the Olympic Games 2004, GAEC has significantly upgraded its infrastructure (equipment and procedures) devoted to the emergency response. State of the art detectors, dosemeters, portable spectrometers, contamination monitors etc, calculation codes for the radiological dispersion in case of a detonation of a "dirty bomb", as well as various protective equipment have been purchased. At the same time the internal emergency response plan has been updated according to the new situation and taking into consideration the recent literature (IAEA, ICRP, etc).

7. GAEC keeps the national radiation protection data base containing data the sources inventory, the dose registry information system, as well as data for all establishments / laboratories using radiation (eg. administrative data, equipment, licenses, personnel, etc). The Information technology department is equipped with five UNIX workstations with networking and printing capabilities. On these workstations run several RDBMS, where all radiological data are stored.

PERSONNEL

The 10 inspectors of the Licensing and Inspection Department are medical physicists or radiation technicians, qualified with an M.Sc. degree in radiation and/or medical physics. Most of them hold also Ph.D. degree.

The staff of the environmental radioactivity department is composed by nuclear physicists (2), medical and radiation physicists (2) and chemists (2). Most of them hold a Ph.D. degree. Specialised technicians (2) are also members of the staff.

The staff of the personal dosimetry department is composed by medical and radiation physicists (2) holding a Ph.D. degree, physicists (2) and specialised technicians (2).

The secondary standards dosimetry laboratory has two medical and radiation physicists holding a Ph.D. degree.

All personnel is adequately trained and participates in various scientific commissions, seminars and courses. The scientific staff of GAEC represents Greece to the various National, European and International Organizations for nuclear technology matters, radiation protection(including non-ionizing radiation), transport of radioactive and fissile materials, radioactive waste management and waste disposal etc.

EDUCATION and TRAINING in RADIATION PROTECTION

GAEC is responsible for providing education, training and continuous training in radiation protection matters. It organizes seminars on regular basis addressed to the scientific and technical personnel of medical, industrial and research laboratories where ionizing radiation is used. It also provides education and training for the personnel of other organizations and services involved in the national emergency response plan, as well as on the job training for future regulators and inspectors.

Moreover, GAEC operates a two years course for Physicists in Medical Radiation Physics in collaboration with the relevant Inter-University Post Graduate Course, where five Greek Universities are involved

(University of Athens, Ioannina, Thessaloniki, Thrace and Crete). This jointly operating course leads to an M.Sc. degree in Medical and Radiation Physics and optionally to a Ph.D. degree. The acquirement of the M.Sc. degree is a prerequisite for a candidate to get the professional license on Radiation Physics, issued by the Ministry of Health after successful examinations. This license is necessary for a physicist to be employed in medical radiation laboratories, where he has a key role in the implementation of radiation protection. The employment of a Medical Physicist in these laboratories is compulsory by the law.

At an international level, GAEC is an IAEA's Regional Training Center for Eastern Europe. Within this frame GAEC operated a Post-Graduate Educational Course on "Radiation Protection and the Safety of Radiation Sources", organized by IAEA and GAEC in collaboration with NCSR "Demokritos", the University of Athens, the National Technical University of Athens and the University of Ioannina. The duration of the course was 18 weeks and was held in GAEC's premises in Athens from 24 February to 27 June 2003. It was attended by 21 scientists from 19 European countries.

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