CONTROL OF RADIOACTIVE SOURCES AND SPECIAL NUCLEAR MATERIAL IN BRAZIL

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Abstract–Résumé–Аннотация–Resumen

CONTROL OF RADIOACTIVE SOURCES AND SPECIAL NUCLEAR MATERIAL IN BRAZIL.

The object of this paper is to describe the steps currently being taken for control of special nuclear materials in Brazil. It describes the control exercised by the International Atomic Energy Agency (IAEA) through the trilateral agreement between Brazil, the United States of America and the IAEA. It also describes the relationship between the National Nuclear Energy Commission and the Institutes and private organizations. The paper deals as well with the criteria which will be applied to the development of this control system as a method of safeguards, with special attention being paid to its effectiveness, since it is also needed as a means of correct administration of these materials by the National Nuclear Energy Commission.

CONTROLE DES SOURCES RADIOACTIVES ET DES PRODUITS FISSILES SPECIAUX AU BRESIL.

Le mémoire a pour objet de décrire les mesures actuellement prises au Brésil pour contrôler les produits fissiles spéciaux. Il décrit les mesures prises par l' Agence internationale de l' énergie atomique à cet effet en application de l' accord tripartite entre l' Agence, le Brésil et les Etats-Unis. Il décrit aussi les rapports existant entre la Commission nationale de l' énergie nucléaire et les instituts et organisations privées. Le mémoire analyse également les critères qui seront appliqués pour mettre au point ce système de contrôle en tant que méthode de garanties, en tenant compte particulièrement de son efficacité puisqu' il est également nécessaire pour assurer l' administration rationnelle des produits fissiles spéciaux par la Commission nationale de l' énergie nucléaire.

КОНТРОЛЬ ЗА РАДИОАКТИВНЫМИ ИСТОЧНИКАМИ И СПЕЦИАЛЬНЫМ ЯДЕРНЫМ МАТЕРИАЛОМ В БРАЗИЛИИ.

Целью доклада является описание принимаемых в настоящее время мер по контролю за специальными ядерными материалами в Бразилии. В нем рассматриваются вопросы контроля, осуществляемого Международным агентством по атомной энергии (МАГАТЭ) по трехстороннему соглашению между Бразилией, Соединенными Штатами Америки и МАГАТЭ. Описываются также взаимоотношения между Национальной комиссией по ядерной энергии, институтами и частными организациями. Рассматриваются критерии, которые будут применяться при разработке этой системы контроля как метода гарантий, с уделением особого внимания ее эффективности, так как она необходима для правильного распределения указанных материалов со стороны Национальной комиссии по ядерной энергии.

EL CONTROL DE LAS FUENTES RADIACTIVAS Y DE LOS MATERIALES NUCLEARES ESPECIALES EN EL BRASIL

El objeto de esta memoria es describir el estado actual del control de materiales nucleares escpeciales en el Brasil, comprendido el control que ejerce el Organismo Internacional de Energía Atómica (OIEA), en virtud del Acuerdo trilateral entre el Brasil, los Estados Unidos de América y el OIEA. Se describen las relaciones entre la Comisión Nacional de Energía Nuclear y otras instituciones y entidades privadas. Se exponen también los criterios que se aplicarán al desarrollarse el sistema de control como método de salvaguardias, prestándose especial atención a la eficacia, indispensable para una correcta gestión de los materiales por parte de la Comisión Nacional de Energía Nuclear.

1. INTRODUCTION

The installation of the first nuclear power plant in Brazil was decided by the Brazilian Government in late 1967. The following year an agreement was signed for mutual collaboration between the National Nuclear Energy Commission (CNEN) and the Centrais Brasileiras S/A (ELETROBRAS) for the establishment of rules to be used for the planning, construction and operation of a nuclear power plant [1]. In the same year, at the request of the Brazilian Government, the IAEA commissioned a study team of international experts to assist the Brazilian authorities in preparing plans for development of nuclear power in Brazil. The primary conclusion of the study team was that the introduction of nuclear power in South Central Brazil could be justified for the early 1980s under the assumptions which were presented [2]. The Study Team advised that the procurement of a proven type of nuclear power plant, to go into operation in 1976/7, was desirable as a means of initiating an effective nuclear power program.

Following this recommendation the Brazilian Government scheduled installation of the Angra Nuclear Power Plant in South Central Brasil, State of Rio de Janeiro, scheduled to be connected to the network in 1976. It will be a 600-MW(e) PWR [3].

The nuclear program that the CNEN intends to pursue in the next few years underlines the importance of nuclear material management in the country. In connection with this, one of the first steps made by CNEN was to send some of its professionals abroad to be trained.

This paper discusses a proposal for the utilization of safeguards methods as a requirement for better management of nuclear materials by CNEN.

2. CURRENT LEGAL ASPECTS OF NUCLEAR MATERIAL CONTROL BY THE NATIONAL NUCLEAR ENERGY COMMISSION

Pursuant to "Lei e Regulamento da Comissão Nacional de Energia Nuclear" [4], Chapter II, Section 1, Art. 4, §I, II, IV, VI and Art. 8, Chapter III, Art. 31, and Chapter IV, Art. 34, 36 and 39, the CNEN has the task of promoting the utilization of nuclear energy, ensuring national security with regard to importation, production, utilization or export of nuclear materials, and maintaining a register of nuclear material resources, reserves or accounts in Brazil. Research, mining, industrialization and trade in radioactive sources and special nuclear material are under federal monopoly. The Presidency of the Republic is the competent authority to orient the National Nuclear Energy Policy.

3. PRESENT RADIOACTIVE MATERIAL CONTROL BY CNEN

After criticality of the first Brazilian nuclear research reactor was reached late in September 1957, the production of small quantities of radioisotopes was initiated, the first shipments being made internally in the country in 1959 [5]. With the growing demand for radioisotopes, mainly for medical uses, the IEA (S. Paulo) had to face the problem of distribution to qualified users. The first regulation for the distribution of radioisotopes came into force, the initial step being the requirement for users to attend special courses in the methodology and application of radioisotopes in medicine, agriculture and industry.

Then, following the creation of the other Institutes and the growth of radioisotope demand in the country, additional courses in the same subjects were given in Belo Horizonte (IPR), Rio de Janeiro (IEN and CNEN) and Piracicaba (CENA).

The Department of Radioactive Material Control (DFMR) is in charge of the registration of all radioactive material imported into or produced in Brazil. All importation of any type of radioactive material, whether by official institutions or private organizations, can be done only if authorized by the CNEN through the DFMR. This therefore is at present the organ which exercises control over all types of radioactive materials in the country.

At present the uses of radioisotopes in Government institutions, other than those having liaison with CNEN, and in private organizations, are under the control of CNEN through its DFMR.

Existing regulations by which CNEN gives permits for the installation and use of teletherapy sources demand a preliminary study for the design and installation, and also a survey before operation. CNEN is now developing a system for the concession of licences for radioisotope uses in the country.

The administration of nuclear materials in the various institutions collaborating with the CNEN in the nuclear program is carried out by those responsible for the programs in which the nuclear material is used.

Concerning the uses of nuclear materials by official research institutions, control is exercised in such a way that special nuclear materials are acquired with the knowledge of DFMR, which is responsible for the import documentation, accounts and documentation pertinent to the agreements by which the materials were obtained.

All the fertile materials produced in the country have their own account at the site of preparation and in a special register at the DFMR, as is the case with thorium and uranium.

4. TRILATERAL AGREEMENT

The first Brazilian research reactors were installed as a result of a Cooperative Agreement signed between Brazil and the United States of America. This Agreement established that the installations and materials put at the disposal of the Brazilian authorities should be used exclusively for peaceful purposes and should be under USA Safeguards [6]. Furthermore, the USA initiated the process of transferring its International Safeguards to the International Atomic Energy Agency [7]. As a consequence, the Trilateral Agreement between the United States of America, the Federal Republic of Brazil, and the International Atomic Energy Agency was signed on 10 March 1967 in Vienna, thus placing safeguards under the responsibility of the IAEA [8]. The first inspection by the Agency occurred on 6 October 1969.

TABLE I. SUMMARY OF THE PRINCIPAL BRAZILIAN FACILITIES UNDER AGENCY SAFEGUARDS

Facility type	Name	Classification and location	Designer and builder	Owner and operator
Swimming-pool Reactor	IEA-RI	Principal Nuclear Facility (PNF): São Paulo (S.P.)	Babcock and Wilcox Co., Instituto de Energia Atômica - Martins Engel Co.	Instituto de Energia Atômica (IEA)
Triga Reactor	Triga-MK-1	PNF: Belo Horizonte	General Atomic Div. of General Dynamics Corp.	Instituto de Pesquisas Radioativas (IPR)
Argonauta Reactor	IEN-R-1	PNF: Rio de Janeiro	Argonne National Laboratory, Mecânica CBV [b]	Comissão Nacional de Energia Nuclear, Instituto de Engenharia Nuclear (IEN)
Subcritical assembly [a]		Other location: São José dos Campos, S.P.	Nuclear Chicago	Instituto Tecnológico de Aeronáutica (ITA)
Subcritical assembly D_2O	Capitú	Other location: Belo Horizonte	Instituto de Pesquisas Radioativas and a complex of Brazilian Industries	Instituto de Pesquisas Radioativas (IPR)
Fuel fabrication plant [c]	Divisão de Metalurgia Nuclear (DMN)	Other location: São Paulo	Instituto de Energia Atômica	Instituto de Energia Atômica (IEA)

a Donated by USAEC.
b Brazilian Company.
c Safeguards applied when safeguarded material is present.

4.1. Safeguards inspection system by IAEA in Brazil

The Trilateral Agreement is based on the Agency's Safeguards System which sets out in detail the procedure for applying safeguards to a facility. Specific references are also made in the Agreement to the Agency's Inspectors Document, which designates inspectors and defines their powers and duties in general terms. Subsidiary arrangements [9] were entered into to define the appointments of and facilities for Agency inspections. Table I gives a summary of the principal Brazilian facilities under Agency Safeguards.

4.2. Some aspects of the facilities under safeguards in Brazil

(a) The IEA-R 1 is a 5-MW research swimming-pool reactor, and is the most important facility from the point of view of safeguards. This reactor [10] is installed at the Instituto de Energia Atômica (IEA), at the University Campus, São Paulo. It is a swimming-pool reactor designed and built by Babcock & Wilcox Co., according to specifications furnished by the Brazilian Atomic Energy Commission. The reactor went critical for the first time on 16 September 1957, and has operated until now without major problems [11].

The reactor operations schedule has been programmed for radioisotope production, training, neutron beam experiments, activation analyses and industrial applications. The reactor operating schedule is 8 hours per operation, four times a week; this has permitted the production of the necessary amounts of the main radioisotopes [5, 12] required for medical and agricultural applications in the country. Radioisotopes with long-lived fission products are now under production [5].

An up-grading of the reactor power to 10 MW is currently under way and is scheduled for the future.

(b) The Triga-MK-1 (originally 30 kW, now 140 kW) is a research reactor used for the production of radioisotopes, educational purposes, training, industrial applications, activation analyses, and radiochemistry. The reactor is located at the Radioactive Research Institute (IPR) at the University Campus, Belo Horizonte, Minas Gerais. Criticality took place in December, 1960. An up-grading of the reactor power to 250 kW is currently under way and is scheduled for 1972.

(c) The "Argonauta" is a research reactor of near zero power designed by the Argonne National Laboratory and constructed entirely in Brazil [13]. It is used in reactor physics, neutron physics, engineering tests, laboratory-scale radioisotope production, and for educational purposes. It is located at the Instituto de Energia Nuclear (IEN), at the University Campus, Rio de Janeiro. Criticality occurred in February, 1965.

(d) Nuclear Metallurgy Division, Instituto de Energia Atômica, São Paulo. This research and development facility has manufactured the fuel elements for the subcritical assembly "Resuco", the core of which has 2378 kg of UO_2 pellets [14]. The first core for the Argonauta Reactor at Rio de Janeiro was also manufactured by the MND, which will also manufacture the enlarged core for this reactor. Its facilities include small-scale production devices for the preparation of fissile material (UO_2 pellets) and the production of nuclear-grade metallic uranium. Bulk material is stored in sealed containers in the locked vault in the IEA Reactor Building. In addition, the facility makes many types of plate fuel elements, including extra-thin-type element plates.

5. FLOW OF NUCLEAR MATERIAL IN SÃO PAULO

Because of its importance the particular case of the flow of nuclear material in São Paulo is described.

The Administração da Produção da Monazita (APM) is the CNEN organ responsible for the industrial processing of monazite sand, from which comes crude thorium oxide, a chemically pure thorium nitrate, rare-earth chlorides, sodium phosphate and sodium diuranate (SDU, yellow cake) as a by-product. Also handled at the APM installation is the production of lithium compounds such as carbonate and hydroxide. The thorium and uranium compounds produced by APM belong to the CNEN and are under the control of the DFMR. Various other products are sold to national industry or are exported (rare-earth chlorides). The APM also undertakes research and development work, including the preparation and purification of uranium, thorium and zirconium compounds.

The sodium diuranate (SDU) produced by APM is sent to IEA at the request of its Chemical Engineering Division (DEQ). This Division is in charge of the development of chemical processes for purification and transformation of nuclear materials. It has in operation two pilot plants for the preparation of nuclear-grade ammonium diuranate (ADU), one based on ion-exchange techniques [15] and the second on solvent extraction. Its facilities include chemical and instrumental analyses such as support and quality control of purified materials, and atomic absorption and spectrofluorimetric analyses by emission spectrography. Nuclear-grade ammonium diuranate and thorium oxalate are the main products. At this Division the SDU is transformed into nuclear grade ammonium diuranate (ADU), either by the ion-exchange process [15] or by solvent extraction purification. The ADU is sent to the Nuclear Metallurgy Division where it is transformed into UO_2 pellets [16].

6. SYSTEM FOR THE CONTROL OF NUCLEAR MATERIALS IN BRAZIL

The establishment of a control system for nuclear material by the CNEN is mainly to ensure economy, safety and health. Although there is a fundamental difference between this aim and that of safeguards, nevertheless the techniques applied can be the same.

Thus the steps for the improvement of a system for the control of nuclear materials in Brazil will be: (1) the issuing by CNEN of control regulations to apply to nuclear materials and equipment subject to its jurisdiction; and (2) the training of people to fulfil this task.

The system to be applied must be such that the CNEN can obtain at any time information on the quantity and location of nuclear material.

This can be achieved through the establishment of a data reporting and inspection system.

Finally, the control regulations to be established shall be subject to periodic reviews with regard to the experience acquired.

7. NECESSARY TRAINING

The activities of persons responsible for safeguards are complex and the team which carries out this function should be very well trained. While safeguards embraces all the activities required for the management of nuclear material, it also includes new equipment and techniques, the study of several subjects and the complete study of the nuclear fuel cycle [17].

It is advisable to expand the CNEN training program to provide a group able to improve nuclear materials management. This group could be trained with the help of foreign experts, which could instruct those people managing nuclear materials, as well as those in correlated research.

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REFERENCES

[1] "Implantação da Primeira Central Nuclear", Relatório Anual da Comissão Nacional de Energia Nuclear (1969) 42.

[2] LANE, J. et al., "Study of nuclear power for South Central Brazil", International Atomic Energy Agency, Vienna, TA Rep. 412, (15 November 1968) 1A.

[3] LYRA, F., SIMON, D., FERREIRA, Jr., H., "The Angra Nuclear power plant (Brazil)", these Proceedings, Paper 801, Vol.6.

[4] "Lei e Regulamento da Comissão Nacional de Energia Nuclear", Brazilian Law No. 4118, 27 August 1962.

[5] LIMA, W.F., "Isotope production and activation analysis using research reactors", Paper presented at a Study Group Meeting on Research Reactor Utilization, Bogotá, Colombia, December, 1967.

[6] SMITH, H.D., "Background of International Safeguards" Proc. Symp. on Safeguards R & D, Argonne (26 June 1967) 14.

[7] SEABORG, G.T., "New Problems in Safeguarding the Atom" Proc. Symp. on Safeguards R & D, Argonne (26 June 1967).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Vienna, INFCIRC/110 (9 April 1968).

[9] "Safeguards Transfer Agreement Between the International Atomic Energy Agency, the Government of the United States of America and the Government of the United States of Brazil — Subsidiary Arrangements" (1969).

[10] SANTOS, M.D S., SARAIVA de TOLEDO, P., "The Brazilian Research Reactor", Publicação IEA No. 11 (1958).

[11] PENTEADO FILHO, A.C., SANTOS, M.D.S., "Operational experience and utilization of the Brazilian 5 MWth swimming pool reactor", Publicação IEA No. 44, September 1961.

[12] da SILVA, CONSTANCIA, P.G., "Produção de Radioisótopos na Divisão de Radioquímica do IEA", Publicação IEA No. 159 (1968).

[13] SANTOS, J., COUTINHO, D., "The Brazilian Argonauta reactor construction", Utilization of Research Reactors (Proc. Study Group Meeting, São Paulo, 1963), IAEA, Vienna STI-DOC-57, 1 (1965) 179.

[14] SANTOS, T.D.S, HAYDT, H.M., FREITAS, C.T., "Fabricaçaõ de Elementos Combustíveis de UO_2 para o Conjunto Subcrítico Re-Suco", Publicação IEA No. 92, March 1965.

[15] ABRÃO, A., FRANÇA Jr., J.M., "Usina Pilôto de Purificação de Urânio por Troca Iônica em Funcionamento no Instituto de Energia Atômica", Publicação IEA No. 219, August, 1970.

[16] SANTOS, T.D.S., BIDWELL, R.M., FREITAS, C.T., HAYDT, H.M., da SILVA, P.S.C.P., "Estudo Experimental das Principais Variáveis para a Produção de Pastilhas de UO_2 para o Reactor Sub-Crítico Resuco", Publicação IEA No. 82, December 1964.

[17] USAEC Rep. WASH-1122, "Research and Development for Safeguards" (1 December 1968) 1.