International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Oversight of Nigeria Research Reactor

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Abstract

The evolution of the legal and regulatory framework for oversight of Nigeria's First Nuclear Research Reactor (NIRR-1) and the organization of the Nigerian Nuclear Regulatory Authority (NNRA) are presented along with the development of the guides applied in the licensing of the various stages of NIRR-1. The submission requirements for the authorization of NIRR-1 were appraised. Also, the regulatory oversight process and the fulfillment of the obligations imposed by international nuclear safety conventions and Nigerian participation in international activities for nuclear safety were discussed.

Keywords: Research reactor; fuel cycle; highly enriched uranium; nuclear material; core conversion; radiation sources; nuclear safety; radiation protection; safeguards; non-proliferation; legal and regulatory infrastructure; neutron activation analysis; inspection.

1. Evolution of an independent regulatory authority

Nigeria's first nuclear activities predated the present national legal and regulatory infrastructure for nuclear safety and radiation protection, so they were largely unregulated or had ad-hoc regulatory oversight. Uranium exploration in Nigeria began in the early seventies with the defunct Geological Survey Department, now Nigerian Geological Survey Agency, and the Nigerian Mining Corporation [1]. In 1976, the Nigerian Atomic Energy Commission Act No. 46 [2] was promulgated, which established two nuclear research centres. Furthermore, in 1979, the Nigerian Uranium Mining Company was established with Total Compagnie Minière of France as its technical partner, to explore and exploit uranium ore deposits in the country.

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Despite these, there was no legal or regulatory control of fuel cycle activities in the country. Nigeria though showed commitment to international nuclear safety, security and safeguards. In 1968, Nigeria signed the Nuclear Non-Proliferation Treaty (NPT) [3] and voted in 1995 for its indefinite extension. In 2001, Nigeria signed the Comprehensive Safeguards Agreement [4] and in 1990, ratified the Convention on Early Notification of a Nuclear Accident [5] and the Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency [6]. With these and the commencement of talks between Nigeria and the IAEA for the supply of a research reactor, in 1995 the Nuclear Safety and Radiation Protection Act No. 19[7] (Act) was promulgated. These and the establishment of the NNRA in 2001 facilitated the installation and commissioning of NIRR-1, covered by IAEA INFCIRC/526 - Project and Supply Agreement of 1996, between the IAEA and the governments of Nigeria and China [8]. Located at the Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Nigeria, NIRR-1 is a 30KW tank-in-pool type reactor with 90% Highly Enriched Uranium (HEU) fuel, designed for teaching, research and for use in Neutron Activation Analysis and limited radioisotope production [9].

2. Legislative and regulatory framework

The Establishment of NNRA in 2001 heralded implementation of the Act, by which NNRA has responsibility for nuclear safety and radiological protection regulation in Nigeria and shall ensure the safe promotion of nuclear research and development, and the application of nuclear energy for peaceful purposes. It is also to perform all necessary functions to enable Nigeria meet its national and international safeguards and safety obligations in the application of nuclear energy; regulate the exploration, mining and milling of radioactive ores and other ores associated with the presence of radioactive substances; and advise the Federal Government on nuclear security, safety and radiation protection.

2.1 Powers

The Act empowered NNRA amongst others, to license operators of nuclear research reactors and critical assemblies, nuclear power reactors and other facilities of the nuclear fuel cycle. It is also to establish in cooperation with other competent national authorities, plans and procedures which shall be periodically tested and assessed for coping with radiation emergencies and abnormal occurrences involving nuclear materials and radiation sources.

2.2 Regulatory control programme

The main elements of NNRA Regulatory Control Programme are issuance of regulations and guidance; granting of authorizations; carrying out oversight functions; emergency planning and response; and ancillary functions.

2.2.1 Regulations and guidance

Shortly after its establishment, the NNRA set up a Technical Advisory Committee (TAC) called the Committee for the Establishment of Licensing Procedure for Nuclear Research Reactors and Licensing of Reactor Operators in Nigeria. TAC was to develop guidelines for siting, design, construction, installation,

commissioning and operation of nuclear research reactors. TAC developed the Draft Guide for Licensing of Nuclear Research Reactors and Reactor Operators in Nigeria [10] (Code). This Guide along with the IAEA Code of Conduct on the Safety of Research Reactors [11] and other relevant IAEA technical documents were applied in the assessment and authorization processes.

2.2.2 Authorization

By the Act, NNRA may issue authorizations for all activities involving exposure to ionizing radiation, including radioactive material, nuclear material, radioactive waste, prescribed substances. Also, no source or practice can be authorized except through a system of application, notification, registration or licensing. Authorization can be in the form of notification, permit, certificate, or licence. The procedure involves notification of practice through assessment, inspection and final authorization.

3. Licensing NIRR-1

The authorization process for NIRR-1 was initiated by the formal request of CERT in 2001 for the retroactive authorization of the Siting and the Design and Construction of NIRR-1. NNRA saw this as a major challenge because the Siting and the Design and Construction of NIRR-1 were done before NNRA was established. In this regard, TAC continued to play an advisory role and its recommendations formed the bases for the authorization. The regulations it developed guided the licensing of the various stages of NIRR-1 development. TAC reviewed the "whole life cycle" of the reactor and established criteria for the authorization of each of the distinct "stages" and conditions governing the safe performance of these activities.

3.1 Methodology for licensing NIRR-1

The IAEA played a key role in developing the capacity of NNRA to authorize NIRR-1 by providing training for the newly recruited staff of NNRA through a training assistance and expert service. TAC applied the Code and the IAEA Code of Conduct on the Safety of Research Reactors to review the "whole life cycle" of NIRR-1 and establish criteria for the authorization of each of the distinct "stages". These were namely, Siting; Design and Construction; Fuel Importation; Commissioning and Operation and; Decommissioning. Conditions were established for the safe performance of these activities.

3.2 Siting

In appraising the Siting, the following parameters were considered: General site description; Man-made and natural phenomena; Geological description; Demography of the area; Surface and groundwater hydrology; and Meteorological description of the NIRR-1 site and its surroundings. This was to establish compliance with the Regulations and the need for imposing additional controls on the already developed site. The only controllable of these factors was the demography of the area. Thus NNRA demanded that no residential, commercial or any other buildings unrelated in objective with NIRR-1 be located within the fenced territory of CERT. NNRA issued certificates for siting, design and construction retroactively to NIRR-1 after its application and safety analysis report were reviewed and approved. The NNRA also issued licence to import nuclear fuel, and for

cross-country transportation of the nuclear fuel between port of entry and CERT.

3.3 Design and construction

Though NIRR-1 was designed and constructed before NNRA, it nevertheless decided to review and assess the basic design with a view to verifying its compatibility with the site. In addition to the report of a review by a hired Civil Engineering consultant, NNRA also reviewed: NIRR-1 Safety Analysis Report; Operational Limits and Conditions of NIRR-1; and Quality Assurance Manuals for Miniature Neutron Source Reactor. Parameters relevant to the design and construction of the reactor were found to be in agreement with the pertinent site parameters and the Code. Additionally, the construction was in agreement with the design. These formed the bases for imposing the licence conditions, which also satisfied the requirements for the retroactive authorization.

3.4 Fuel importation

Fuel importation, was greatly influenced by the heightened concern for security arising from the September-11 2001 incident. In addition to IAEA requirements relating to Category II Nuclear Materials, NNRA reviewed and upgraded the security arrangements in CERT submissions and integrated the fuel shipment and the commissioning program. This eliminated any intermediate storage for the nuclear fuel. Strict conditions were imposed such that the fuel was evacuated from the port of entry within 1 hour of arrival. Reactor core assembly also commenced about 36 hours of fuel arrival at CERT. Furthermore, security during transportation between the port of entry and the reactor site was the responsibility of the Federal Government of Nigeria. Consistent with government posture on nuclear safeguards and nuclear non-proliferation, the NNRA also gave a written undertaking to the country of origin of the fuel, that the fuel would be used solely for peaceful purposes and would not be used for the development or manufacture of any nuclear explosive device or for any military purpose. It would also only be installed or used in a facility under IAEA safeguards. Additionally, the fuel would not be transferred beyond the territory or jurisdiction of the government of Nigeria without the prior consent of the government of the country of supply and would be under appropriate physical protection with reference to the recommendations of IAEA.

3.5 Commissioning and operation

The NNRA reviewed the Commissioning Program and Procedures by considering the conditions and preliminary operational limits as well as the schedule and procedures for shipment of packages containing fuel elements. The equipment installation report on NIRR-1 and the maintenance manuals were also assessed. Also considered were the programmes for systems maintenance, testing and inspection; radiation monitoring; and physical security. Authorization for commissioning and operation of the reactor were issued only after finalizing the arrangements for the shipment of the fuel to Nigeria.

3.6 Decommissioning

A tripartite agreement between IAEA, China, and Nigeria provided for the return of the spent fuel to China. Further developments of this aspect of the regulatory provisions were ongoing.

4. Regulatory inspections of NIRR-1

With the delivery of the first nuclear fuel to Nigeria in December 2003 and the commissioning of NIRR-1 in September 2004, Nigeria started receiving annual IAEA Safeguards Inspectors for verification of nuclear material accountancy and the performance of design information questionnaire. This was pursuant to Nigeria's obligations under the Protocol Additional to the Comprehensive Safeguards Agreement, which Nigeria signed in 2001[12]. The inspections included physical inventory, verification of nuclear materials and design information verification. With the establishment of the State System of Accounting and Control, Nigeria commenced the submission of annual reports on all safeguarded nuclear material and activities covered under the Additional Protocol Declaration. These included, Material Balance Report; Physical Inventory Listings; Inventory Change Report and; Nuclear Material Accounting.

NNRA also carried out quarterly safety inspections to assess compliance with the Act; the approved Operational Limits contained in the Final Safety Analysis Report as well as the Terms and Conditions of the Reactor Operation Licence. In August 2005, non-compliance issues were discovered during one of these inspections, resulting in enforcement action. CERT was directed to stop operating the reactor until among others, its licenses were renewed. It could however carry out the weekly water purification and maintenance. In 2009, a performance assessment was carried out on NIRR-1 safety. NIRR-1 had operated since inception without any major incident; however, concerns over the need to maintain and enhance safety levels led to significant emphasis on strengthening the international safety regime. Thus in November 2009, an IAEA Integrated Safety Assessment of Research Reactors (INSARR) Mission visited CERT under a Technical Cooperation Project. NNRA participated as an Observer during the Mission. The INSARR Mission was designed to address the general operational safety of NIRR-1 and to carry out a comprehensive and independent safety assessment. It covered the following areas amongst others: quality assurance programme; safety documentation; conduct of operations and procedures; record keeping; maintenance programme and modifications; personnel training and qualification; radiation protection programme including dose records, waste management, emergency planning and preparedness; organizational structure as regards safe operation of the reactor; and administrative organization structure for safety matters. At the end of the mission, IAEA made recommendations including establishment and implementation of periodic testing program for the items important to safety. NNRA later included some of these recommendations in CERT Operational Licence Conditions, especially for the performance of periodic operability checks and calibration tests for some defined safety parameters and the update of the Safety Analysis Report to reflect the actual status of the reactor facility. This INSAAR was followed by a one-day Technical Meeting held in June 2010 attended by participants from seven Ministries, Departments and Agencies to review and assess the performance of NIRR-1 right from when it became critical. One of the recommendations of the meeting was to extend the life of the Reactor Operation Licence from one to two years. This was implemented by NNRA.

To further achieve threat reduction on vulnerable radioactive sources and nuclear materials, the NNRA in partnership with the IAEA and the United States Department of Energy carried out physical protection assessment and upgrade on the facility. It was funded by the IAEA Office of Nuclear Security. The scope of the work included the provision of intrusion detection equipment; installation of remote monitoring equipment; and

the provision of training for CERT personnel. The physical security upgrade was done in 2011.

5. Reactor core fuel conversion from HEU to LEU

CERT in 2010 notified NNRA of its research collaboration with the United States of America aimed at the conversion of the NIRR-1 core from HEU to Low Enriched Uranium (LEU) fuels. Consequently CERT made a presentation on its preliminary findings on the research work to NNRA in December 2010. From the presentation it was clear that CERT was making progress in this respect, though CERT was yet to make a formal application for authorization for the conversion to take place. By 2014, there was report containing results of activities performed for the conversion of from HEU to LEU fuel [13]. Furthermore, the conversion was not foreseen to present any new potential accidents nor did it increase the consequences of any of the postulated design basis accidents identified in the current approved Safety Analysis Report.

6. Challenges

At the time of the authorization of NIRR-1, NNRA was in its infancy and saw the process as a major challenge because NIRR-1 had been sited, designed and constructed before NNRA was established. The necessary regulatory and guidance documents which were to be applied in the authorization process were largely unavailable and had to be newly developed. Additionally, because most NNRA staff were newly recruited and inexperienced, NNRA had to rely on the services of a TAC, composed of multi-institutional members. This significantly increased the overhead cost of the process. The development of NNRA manpower also posed a major challenge. The special skills needed for oversight of NIRR-1 were acquired through technical cooperation with the IAEA and by expert services sponsored by the IAEA and through international cooperation with other friendly countries.

7. Conclusion and recommendations

NIRR-1 has operated safely and without any significant incident or accident. As a pioneer in Nigeria, it has inspired and presented a veritable tool to many Nigerian scholars and researchers in their various endeavours. It shall continue to provide important benefits, including research, education, materials testing and medical and industrial applications. In this regard, it is important to ensure that the use of NIRR-1 remains safe, well regulated and its environmental conditions remain sound. To strengthen regulatory infrastructure, the Draft Guide for Licensing of Nuclear Research Reactors and Reactor Operators in Nigeria, should be approved by the Federal Ministry of Justice.

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