REGULATORY ACTIVITIES OF THE NNRA AND CLIENTS AND LICENSEES

1. THE PETROLEUM INDUSTRY - OIL AND GAS

Nuclear Techniques

- Well Logging Techniques- Used to help to distinguish the shale content of sedimentary rocks for litho-logical identification, to indicate how porous the rock is and whether it is likely to contain hydrocarbons or water, to indicate the presence of gas to determine chlorine, or salt water, content of the rocks
- Nuclear Gauging - installed to monitor or control the density of fluid flowing through pipelines, fluid levels in vessels and to detect the interface between fluids of different densities, such as the water, oil and gas interfaces in separators. e.g. on crude oil export lines.
- Multi-Phase Flow Meters (MPFMs) - They are used to measure the phase fraction of oil, gas and water in the flow from an oil well. Installed at different locations in refineries for various activities of the flow lines.
- Radiotracers Technique - These are radioactive liquids which are injected by specialized equipment into selected oil and gas field wells.
- Industrial Radiography -Oil and gas operators commonly employ service companies to carry NDT to ensure that all constructions and fabrications are completed to the required standard and to check the integrity of petroleum pipes by identifying flaws in welds to prevent leakages and where and whenever such leakages occur, mend them

Radiation Sources Used

- Americum-241 - To help determine where oil wells should be drilled
- Cesium-137 - To measure and control the liquid flow in oil pipelines, to tell well owners whether oil wells are plugged by sand
- Cobalt-60 -By oil service companies to improve the safety and reliability of industrial fuel oil burners
- Curium-244 - To analyze material excavated from pits and slurries from drilling operations
- Iridium-192 - By NDT companies to test the integrity of pipeline welds, boilers and oil storage tanks and for detecting leakages in buried pipelines
- Tritium-3 - In gauges to measure oil flow in pipes and oil platforms and for geological prospecting for crude oil and gas
- X-Ray Scanners – For security and baggage scanning

NNRA Clients/Licensees

- Well Owners – SPDC, NPDC, AGIP, TOTAL, CHEVRON, MOBIL, SEPLAT, AMNI etc
- Source Owners (Gauges) – Chevron, TOTAL, MOBIL, PHRC, KRPC, WRPC , etc
- Source Owners (Well Logging) – Schlumberger, Halliburton, Baker Hughes, Drillog,
- Source Owners (Tracer Techniques) – CORELAB, GEOPLEX, African Oilfield , etc
- Source Owners (NDT) – Seipem, Oceaneering, RTD, SGS Inspection, OZMA , etc
- Rig Owners – Shelf Drilling, Pacific Drilling, Seadrill, etc
- Security Scanning (X-Ray) – Chevron, TOTAL, etc
- Transporters (Marine) – Bourbon Oil, T1 Marine, Projecteni, etc
- Transporters (Land) – Sailbond, IAL, Daudeen, etc
- Waste Management Consultants (NORM) – MATRIX, etc
- Dosimetry Services Providers (Personnel Monitoring) – RST, CERT, LASURMS, c
- Radiation Safety Advisers (Advising Clients) – NSC, RST, CERT, etc
- Medical X-Ray Facilities – NNPC , MOBIL, CHEVRON, TOTAL, SPDC clinics, etc

2. THE HEALTH SECTOR

Techniques

i. Radiotherapy

- Radiation therapy is the use of ionising radiation such as high energy photons or particles to *treat* patients with cancer and occasionally non-malignant conditions
- Radiation therapy is an effective way to treat many kinds of cancers in almost any part of the body
- More than half of all people with cancer are treated with radiation

ii. Nuclear Medicine

- This is a medical specialty that uses radioactive materials to both diagnose the body and treat disease;
- Documents organ function and structure;
- Uses relatively small amounts of radioactive materials (radiopharmaceuticals) to diagnose and treat which are substances that are localized in specific organs, bones, or tissues;

iii. Diagnostic and Interventional Radiology - X-Ray

- provides static (radiographic) images using either x-ray film and intensifying screens or digital image receptors;
- may be used to examine most parts of the body such as the chest, abdomen, pelvis, head, spine, extremities etc.;

Radiation Sources

Radiation Therapy

- Superficial
- Othovoltage
- Teletherapy Co-60
- Teletheapy LINAC
- Brachytherapy
- Brachytherapy – afterloading Cs-137, Ir-192

Nuclear Medicine

- Technetium-99m (^{99m}Tc) used for diagnostic nuclear medicine procedures
- Iodine-131 (^{131}I) used for therapeutic nuclear medicine procedures
- *Gamma Camera* (equipment)

Diagnostic and Interventional Radiology

- Conventional X-ray Machine
- Mammography Machine
- Fluoroscopy Machine
- Mobile X-ray Machine
- CT Scan
- Dental radiography

3. THE MANUFACTURING SECTOR

Techniques

Quality Control

- Density: rubber, oils, fabric, paper, etc
- Thickness: paper, glass, steel, plastic films
- Level: beverages, cooking oil

Process Control

- Density: cement, mud, liquids, chemical products
- Level: vessels, silos, chemical products, minerals
- Moisture: glass, cement, minerals

Radiotracers

- Fertilizer Plants, Cement Factories, Sulphuric Acid Plants, etc

Radiation Sources

i. Gauges can be categorized by their mode of operation

- transmission
- backscatter

ii. Type of radioactive source used

- Gamma, Beta and Neutron

Sources

- X-ray
- Cesiums-137
- Cobalt-60
- Krypton-85 (encapsulated gas)
- Strontium-90 (foil source)
- Promethium-147 (foil source)
    - Americium-241
    - Americium-241/beryllium
    - Plutonium-238/beryllium

NNRA Clients/Licensees

- Delta Steel Co. Ltd.
- Classic Beverages Nig. Ltd.
- ExxonMobil
- Wempco Steel mills Co. Ltd.
- Notore Chemical Industries Ltd
- BUA International Limited
- Dangote Cement
- Obajana Cement
- African Wood Industries Nigeria Limited
- Peugeot Automobile Nig.Ltd
- Nigerian College of Aviation Technology, Zaria
- British American Tobacco Zaria
- Kaduna Refinery And Petrochemical, Kaduna
- Dahua Paper Company Limited
- Tempo Paper Pulp and Packaging Ltd, Ogun State
- Nigeria Bottling Company plants
- United Nigeria Textiles Ltd Kaduna
- Nigeria Breweries, Kaduna

4. CUSTOMS AND SECURITY SCREENING

Techniques

- X-ray inspection systems for cargo containers have now become a standard feature in many ports including those in Nigeria
- This rapid adoption has been accelerated by the needs of port security, but made practical by the systems' unique ability to non-destructively penetrate entire containers and generate images of the contents in just a few seconds
- Even at this large scale, the resulting images are comparable to those obtained through traditional baggage scanning at airports and capable of identifying objects smaller than a baseball
- Consequently, these systems are commonly employed for manifest verification and contraband interdiction in a variety of environments
- Based on intelligence gathered by officials, such as suspicious activity and risk assessment, officers at Port decide which cargo containers they will scan
- The truck then either stays stationary while the scanner moves across the whole vehicle or else the scanner stays put while trucks drive through the device.
- When there's something found, an alarm goes off
- Officials inside the scanner's cabin can also see what's inside and if the material is 'organic' or not, which could indicate illegal substances

Radiation Sources

- 25 High Energy X-Ray for Container scanning
- Radiation Portal Monitors (RPMs) for illicit trafficking
- Cargo and Baggage X-ray Scanners
- Radioisotope incorporated security scanning equipment

NNRA Clients/ Licensees

- COTECNA – Sea Ports
- SGS Scanning – Sea Ports
- Globascan - Sea Ports
- SAHCOL - Airports
- NAHCO - Airports
- Oil Companies - TOTAL, CHEVRON
- Central Bank
- Embassies
- Julius Berger
- Hotels
- Security Outfits
- Etc

5. THE CONSTRUCTION INDUSTRY

Techniques

Dam compaction

- Nuclear density meter is used to check the density of the roller compacted concrete after compaction is carried out.
- The number of passes of the vibratory roller is manually counted to ensure the adequate compaction of roller compacted concrete layer

Road- Density of Asphalt in a Paving Mix

- Building a road isn't easy; there are many layers that help make it strong enough to support big trucks and cars.
- Each layer must have the right density and layers of gravel must have the right amount of moisture.
- Construction crews measure density and moisture with special nuclear gauges that are powered with sealed radioactive sources.
- Nuclear gauges use radioactive sources to measure the thickness, density or make-up of a wide variety of material or surfaces

NNRA Clients/Licensees

- SCC, Julius Berger, etc

6. THE MINING SECTOR

All the mining companies in Nigeria is currently un undergoing process of getting licenses from the NNRA as radiation in mining involves exposure to naturally occurring radioactive material (NORM) primarily uranium, thorium, and their decay products, such as Radon-222, which release alpha, beta, and gamma radiation. Miners face significant risks through inhaling dust and radon gas, or external exposure from ore bodies, especially in uranium, coal, and mineral sand mining

Techniques

- Uranium exploration and mining and other processing
- Mining activities associated with radioactive ore/norm residues
- Transportation of material contaminated with naturally occurring radioactive material (norm)
- Advanced nucleonic instrumentation for security and environmental monitoring
- Transiting uranium material through Nigerian territory
- Processing, storage and abandonment of Mine Tailings in the form TE-NORM

Primary Risks of Radiation in Mining

The main radiological hazard, especially in underground mines, is the inhalation of radon gas and its short-lived decay products (Po-214, Po-218, Bi-214 and Pb-214), which deposit in the respiratory tract.

Sources of Exposure:

- NORM: Uranium, thorium, and Potassium-40 found in ore.
- Inhalation: Radon gas and radioactive dust.
- Ingestion: Contaminated food or water.
- External: Gamma radiation from ore bodies and processed waste.

Affected Activities

While uranium mining is the primary concern, other industries like rare earth mining, phosphate mining, and industrial mineral processing (oil/gas) can generate significant NORM.

Environmental Impact

Tailings, mine water, and waste rock can contaminate surrounding environments, leading to long-term radiation exposure for nearby residents.

Safety Measures

Mitigation involves ventilation systems, dust control, and, in some cases, the use of nuclear technology (e.g., density gauges) under strictly controlled, regulated, and monitored conditions.

7. AGRICULTURE AND WATER RESOURCES

Techniques

Genetic Variability

- Ionising radiation is used in plant breeding to produce new genetic lines. Some examples have been sorghum, garlic, wheat, bananas, beans, avocado and peppers. The new lines are more resistant to pests and more adaptable to harsh climatic conditions

The Sterile Insect Technique (SIT)

- This consists of irradiating laboratory-reared male insects before hatching to sterilise them then releasing them in large numbers in the infested areas. When they mate with females, no offspring are produced. With repeated releases of sterilised males, the population of the insect pest in a given area is drastically reduced.

Food Preservation through Irradiation

- Food irradiation is the treatment of food by ionizing radiation
- Radiation at appropriate doses can kill harmful pests, bacteria, or parasites, and extend shelf-life of foods

Fertilizers enhancement

- 'labeled' with a radioactive isotope, such as ^{15}N and ^{32}P, provide a means of finding out how much is taken up by the plant and how much is lost

Water resources Management

- radioactive liquid tracers injected into water supply:
- underground - trace and measure the extent of underground water, provide information about origin, age and distribution and the interconnections between ground/surface water and renewal systems
- surface - evaluate leakage through dams, dynamics of lakes and reservoirs, flow rates, river discharge measurements, sedimentation rates

Animal Production And Health

- A programme in which radio-immunoassay techniques are used to measure the hormonal changes during the reproductive cycle of cattle and buffalo is leading to enhanced reproductive efficiency through better management practices and more efficient use of artificial breeding techniques

NNRA Clients/Licensees

- Institute for Agricultural Research (IAR), ABU Zaria;
- National Veterinary Research Institute, Vom
- International Institute for Tropical Agriculture (IITA) Ibadan
- National Animal Production Research Institute (NAPRI) Zaria

8. EDUCATION, RESEARCH AND SERVICES

Techniques

A wide range of high, intermediate and low risk radiation sources (radioactive and electrically generated) are also used in teaching, research and development by laboratories and universities. In Nigeria we have:

- 8 X-ray Diffractometers and Spectrometers
- 13 registered sealed calibration sources for teaching
- Open radioactive sources for research
- Three 14 MeV Neutron Generators
- Two 8 MeV van de Graff accelerator

NNRA also accredited several hundreds of entities in Nigeria that offer special radiation services such as:

- Dosimetry Service Provider (External)
- Land Transportation of Radioactive Materials
- Marine Transportation of Radioactive Materials
- Air Transportation of Radioactive Materials
- Engineering/Maintenance Services Provider – Oil And Gas
- Engineering/Maintenance Engineering Services Provider (Other Applications)
- Sale And Supply of Equipment Incorporating Ionizing Radiation Sources
- Radiation Safety Adviser/Calibration Services
- Freight Forwarder of Radioactive Sources
- Radioactive Wastes Management
- Radioactive Waste Management Consultant
- Interim Radioactive Waste Storage Facility
- Radioactive Waste Management Facility

9. THE NIGERIA NUCLEAR RESEARCH REACTOR (NIRR-I)

Location and Technical Specification

- The Reactor is located at the Centre for Energy Research and Training (CERT) at Ahmadu Bello University in Zaria, Kaduna State, Nigeria.
- It is a pool type reactor owned by the Nigeria Atomic Energy Commission (NAEC) with the assistance of the International Atomic Energy Agency (IAEA) under a Technical Cooperation (TC) Programme
- The reactor is a 30 kW Miniature Neuron Source (MNSR) installed in 1999
- It attained criticality on 3rd February 2004
- Was commissioned in 2004 and Licensed by NNRA on 1st June 2004
- It has Neutron flux: ~10^{12} $cm^{-2}s^{-1}$ and One central control rod used for regulating power level, compensating for fuel burnup and for startup and shutdown
- It is a small, compact and safe reactor that employs HEU as the fuel, light water as the moderator/coolant, and beryllium as the reflector
- Was designed for use in universities, hospitals and research institutes mainly for NAA, limited production of short-lived radioisotopes and training.

Economic Use of NIRR-1

- Geochemical and soil fertility mapping of Nigeria
- Trace element abundances in Nigerian crude oils and lubricants.

- Determination of nutrients and heavy metals in Nigerian food and beverages as well as bromine and iodine in medicinal herbs by epithermal NAA
- Use of k0-epithermal NAA techniques for the determination of U, Th, K in archaeological materials
- Elemental analysis of flesh, bones and gills of popularly consumed fish in Nigeria to improve nutrition and health

Future Economic Use of NIRR-1

- Study of the levels of toxic and heavy elements in wells, rivers, bottled and public water supplies, as well as monitoring of pollutants in air, water and sediments.
- Doping trace elements in ceramics and silicon wafers.
- Elemental analysis to examine evidence from crimes such as hair, nail and serum samples, and for the identification of the age of pottery and metal artifacts

10. THE GAMMA IRRADIATION FACILITY (GIF)

Location and Technical Specification

- The GIF, a semi-commercial multidisciplinary facility, was acquired by the Federal Government of Nigeria mainly for the application of irradiation technology in Nigeria for socio-economic development
- The facility located at the Nuclear Technology Centre, km 32 Zuba-Lokoja road, Abuja
- It was commissioned and licensed by the NNRA in the third quarter of 2006 under the Sheda Science and Technology Complex (SHESTCO) Management
- In 2008 the management of the facility was transferred to the Nigeria Atomic Energy Commission (NAEC), the current operator
- *The facility is the largest on the continent of Africa with initial activity of the Cobalt-60 as 300,000 Ci* (upgradeable to *1,000,000 Ci*)
- The GIF GS1000, Panorama IV Cobalt-60 wet source was manufactured by Framatome ANP GmbH an AREVA and Siemens Company based in German

Economic Use of the GIF

- The multipurpose gamma irradiation facility was acquired as a pilot plant by the Federal Government of Nigeria for application in agriculture, medicine and industry with emphasis on:
- Sprout inhibition of onions, potatoes, yams, etc. to preserve them in order to make the products available all the year round

- Insect disinfestations of grains and complete elimination of insects in products (e.g. maize, beans, sorghum, millet, etc.), cash crops (e.g. cocoa, kola nuts, etc.) and flour products
- Reduction of microbial load in spices (e.g. chilli pepper, ginger, etc.) particularly for export;
- Microbial decontamination of meat, pork, poultry, fish, seafood (e.g. shrimps, lobsters, crabs, etc) for local consumption and for export;
- Delay ripening in fruits (e.g. mangoes, bananas, plantains, tomatoes, etc.); in other to get them to local markets and for export particularly to West Africa Sub-region
- Plant breeding to boost food production through the production of high yielding and disease resistant crops and plants (e.g. roots and tubers such as yams, low cyanide cassava, etc.);
- Sterile insect techniques (SIT) in the eradication of pests that destroy farmland and adversely affects animal production;
- Radio-sterilization of medical devices, pharmaceutical and cosmetic products and packages (e.g. syringes, catheter, swabs, sterile solutions, hypodermic needles, surgical blades, surgical gloves, biological tissue, blood, blood transfusion equipment etc.)
- Cross-linking in polymers to improve mechanical, electrical and thermal properties of plastics (e.g. cable & wire products, plastic pipes for hot water in hotels and other house use, etc.) and vulcanization of our natural rubber latex;
- Application in the Plywood and Wood Industry particularly in the production of particleboards using saw dust and waste wood shavings