GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY

RAJYASABHA
UNSTARRED QUESTION NO – 2084
ANSWERED ON 07/08/2025

PROGRESS IN ATOMIC RESEARCH AND NUCLEAR SAFETY

2084. SHRI AKHILESH PRASAD SINGH

Will the PRIME MINISTER be pleased to state:-

(a) the details of significant scientific or technological milestones which have been achieved in India's indigenous atomic research programs during the current year;
(b) the details of global collaborations or partnerships which are currently in place to improve nuclear safety protocols, enhance research capabilities and facilitate technology exchange; and
(c) the details of the preparedness and emergency response systems which have been developed to safeguard civilian populations living near atomic energy sites?

ANSWER

THE MINISTER OF STATE FOR PERSONNEL, PUBLIC GRIEVANCES & PENSIONS AND PRIME MINISTER'S OFFICE (DR. JITENDRA SINGH)

(a) A number of notable achievements have been realized under India's indigenous atomic research initiatives this year, spanning the domains of basic science, healthcare, nuclear agriculture, water treatment etc.

1. **Basic Science**:
   i. Research work from Indus-2 beamline led to deposition of 207 protein crystal structures to the international repository of Protein Data Bank (PDB) for research purposes.
   ii. Significant astrophysical discovery such as gamma-ray flares from galaxy OP 313 which is 8-billion-light year-away from the Earth was made by the MACE telescope.

2. **Health Care:**

i. A novel PEM-based electrolyser system was developed and deployed for de-deuteration of Oxygen-18 enriched water for medical application.

ii. Molybdenum-100 was successfully enriched to 96% for medical applications.

iii. DAE has received Indian patent for the innovation titled ‘A Chlorophyllin Containing Pharmaceutical Composition for Prevention of Pathogenesis of Coronavirus".

3. **Nuclear Agriculture**:

i. Raichur Trombay Sorghum-43 (RTS-43), a new sorghum mutant variety for Rabi season was released & Gazette notified for cultivation in Karnataka. This variety has early, synchronized flowering, white lustrous, bold seeds, improved mineral content & good roti making qualities.

ii. Area of cultivation for 6 Trombay oilseed crops has been extended to more states through Gazette notification. These include groundnut: CGTM, TAG73; Mustard: BBM1, THPM1; linseed TL99 & Sesame TLT10.

iii. Radiation based standard operating procedure (SOP) has been developed by Bhabha Atomic Research Centre(BARC) for extending the shelf-life of ‘Badami’ mango for sea-route export.

4. **Hydrogen Production**:

i. BARC has successfully developed, installed and demonstrated a compact 0.5 MW Alkaline Water Electrolyser for hydrogen production at Kochi Airport. This indigenous system, fabricated in collaboration with Bharat Petroleum Corporation Limited (BPCL).

A closed-loop thermochemical process was developed and demonstrated for extracting hydrogen from hydrogen sulphide (H_2S), converting a harmful refinery by-product into a clean energy source.

5. **Water treatment**:

i. The hgSBR wastewater treatment technology was successfully deployed for treatment of sewage water at Maha Kumbh Mela- 2025 at Prayagraj.

6. **Technology Transfers**:

For dissemination of spin-off technologies, ten new technologies were released, 29 licences issued, and two more AKRUTI centres established during the year.

7. National Facilities for Research:

Two Synchrotron Radiation Sources (SRS) Indus-1 and Indus-2 continued to operate as National facility in round-the-clock mode. More than 1000 user experiments were carried out on Indus beamlines by various Institutes and industries leading to publication of more than 200 research papers.

Another facility of Infrared-Free Electron Laser (IR-FEL) developed and in operation at Raja Ramanna Centre for Advanced Technology (RRCAT) complements the Synchrotron Radiation Source by providing high brightness, short pulsed photons at energies tunable from 25 - 100 meV for the frequency domain as well as time domain studies of samples from different fields of science.

8. Electron Beam Sterilization of 10 Million Medical Devices:

E-beam Radiation Processing Facility (EBRPF), powered by an indigenous 9.5 MeV, 6 kW E-Linac, began commercial electron beam sterilization of medical devices in October 2022 with Food and Drug Administration (FDA) approval and continued to operate under robust and strict Medical Devices Rules. This year on 16th May 2025, it achieved the milestone of sterilizing 10 million devices, especially the last 5 million medical devices are processed in just five months.

9. Fast Breeder Test Reactor (FBTR):

At Indira Gandhi Centre for Atomic Research (IGCAR), Fast Breeder Test Reactor (FBTR) has successfully operated for the last 39 years, achieving the rated name plate capacity of 40 MWt, and continued to operate at maximum power level of 40 MWt demonstrating the technological viability of fast spectrum reactors and the indigenous capabilities. FBTR has been the Test–bed for the irradiation of fuels and structural materials, training and qualification of human resource for fast reactors. U-233 fuelled Kalpakkam Mini Reactor (KAMINI) is continuing its successful operation for neutron radiography of active & inactive components and activation analysis.

Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP), was hot commissioned during April 2024. Subsequently, three successful campaigns for processing FBTR spent fuel were completed. 60 FBTR spent fuel pins with a burnup of 155 GWd/ton were processed achieving its full design capacity. The recovery of

Neptunium-237 from the PUREX process stream has been successfully demonstrated. About 1800mg of Np-237 has been separated from the uranium product stream. Neptunium-237 can be used to produce Plutonium-238, a source material for Radioisotope Thermoelectric Generators (RTG).

Design, development and manufacture of Horizontal Sub-Assembly Grappler Mechanism (HSAGM), a First of Its Kind (FOIK) equipment to handle the PFBR Sub assemblies at Head End cells of the Head End Facility (HEF) of Demonstration fuel Reprocessing Plant (DFRP) or Fuel Reprocessing Plant (FRP) of Fast Reactor Fuel Cycle Facility (FRFCF) has been completed. The indigenous production of Sr-89 is an important societal need and a valuable import substitution; it is a pure beta emitter with a half-life of 50.5 days and used for palliative care of bone metastatic cancer. Production of Sr-89 with high specific activity at Fast Breeder Test Reactor (FBTR), Kalpakkam was successfully demonstrated. The product satisfied all the Quality Control Parameters as per the US, European and International Pharmacopeia. Bio-distribution studies completed.

10. Cyclotron:

A major milestone of the country's first K500 Superconducting Cyclotron has been successfully achieved by accelerating and extracting out first harmonic heavy ion beams (Nitroge 4^+ up to 420MeV, Oxygen 5^+ beam up to 363MeV, Neon 6^+ beam up to 438 MeV energy) and delivered to the users for nuclear physics experiments in frontier research. Currently, 30 MeV/A heavy-ion beam energy from K500 Superconducting Cyclotron, is the highest beam energy available in India.

In the 30 MeV Medical Cyclotron facility, the following radioisotopes have been produced on trial basis.

- PET radiopharmaceutical, Copper-64-Chlodide (for Therapy + Diagnostic of cancer)
- SPECT radioisotope Iodine-123 (for Diagnostics of thyroid cancer) produced from solid target of Tellurium-124 (Jointly with BRIT).
- Germanium-68/Gallium-68 generator produced from solid target of Gallium-Nickel alloy electroplated target (Jointly with BRIT).
- SPECT radioisotope Lead-203 (Pb-203) (for imaging and also cancer therapeutic applications) produced, first time in India, on trial basis from low cost natural thallium target (Jointly with BRIT).

(b) Global Collaboration or Partnerships which are currently in place to improve nuclear safety protocols, enhance research capabilities and facilitate technology exchange are as follows:

1. Indian Institutions Fermilab collaboration (IIFC) in the field of Physics and advanced technologies for high intensity proton accelerators with Fermi National Accelerator Laboratory
2. Collaboration for International Thermonuclear Experimental Reactor (ITER),

3. Collaboration with Jules Horowitz Reactor (JHR) with France
4. Collaboration for establishing LIGO-India Project between executing agencies DAE, India and National Science Foundation (NSF)-USA, California Institute of Technology (Caltech)- USA, Massachusetts Institute of Technology (MIT)-USA.
5. Indian Institutions and Fermilab Collaboration (IIFC)-USA.
6. Collaboration with French Atomic Energy and Alternative Energies Commission (CEA), France in various area of nuclear research; some of the active implementing agreements are listed below:
    i. Under sodium defect detection using ultrasonic guided waves
    ii. Phased array ultrasonic inspection of thick austenitic Stainless steel
    iii. R&D on severe accidents in SFRs (Sodium Fast Reactors)
    iv. Test in flowing sodium of electrochemical sensors for oxygen
7. India is a contracting party to the Convention on Nuclear Safety (CNS) and actively participates in the regular peer review process under the CNS. Safety status of Nuclear power plants is regularly reported in the national reports which are peer reviewed in the review meetings that take place once in three years.
8. Collaborations with Global high-energy physics research programme at CERN-Geneva, Switzerland and Brook Haven national Laboratory, USA. Experimental research on exotic nuclei, radioactive ion beams are performed through international collaborations, such as, FAIR, Germany and SPIRAL2, France. The research contract signed with IAEA, Vienna, is to perform the Research Project entitled "Updating and Improving Nuclear Level Densities for Applications", which forms part of the IAEA Coordinated Research Project "Updating and Improving Nuclear Level Densities for Applications". Department of Atomic Energy (DAE) is involved in the accelerator based research programme of Fermilab-USA. The 650 MHz (beta~0.6) superconducting RF cavity has been made under the collaboration of Indian Institutions (IISC) and Fermilab, USA.
9. Atomic Energy Regulatory Board (AERB) participates in various Technical and consultants' meetings organised by International Atomic Energy Agency (IAEA) on a range of topics related to Nuclear Power plants, fuel cycle facilities, radiation facilities, transportation of radioactive materials and illicit trafficking of radioactive materials. AERB has also been participating in IAEA Coordinated research Programme (IAEA-CRP). AERB takes part in the development of IAEA documents. AERB experts are serving as members in IAEA Safety Standards Committees. AERB plays an active role in strengthening the global safety regime and towards this contributes in various meetings, peer review missions and development of safety standards of IAEA. It also utilises experience gained through these safety-cooperation activities towards further augmenting safety regulatory system within India.

10. India is participant in two committees (Committee on Nuclear Regulatory Activities (CNRA) and Committee on the Safety of Nuclear Installations (CSNI)) of Nuclear Energy Agency (NEA). NEA is a specialized agency within the Organization for Economic Co-operation and Development (OECD), an intergovernmental organization of industrialized countries, based in Paris, France.

11. AERB participates in annual meetings of CANDU Senior Regulators, organized by IAEA, for exchange of information on issues specifically related to safety of PHWRs. AERB is one of the key contributors in CANDU PSA Working Group established by IAEA as suggested by CANDU senior regulators forum. AERB is a member of VVER Regulators Forum and regularly contributes to its various activities through participation in its working groups namely PSA Working Group and Reactor Physics Working Group.

12. AERB joined the Atomic Energy Research (AER), Hungary as member organization in 2019. AER is an international community of researchers, engineers and operators from countries running the VVER type nuclear reactors. The objective of AER is to promote information exchange among VVER utility staff, Designers, R&D institutes and Safety authorities. AERB attends meetings of AER scientific council and its working Groups. AERB has established formal cooperation MoUs/arrangements for the Exchange of Technical Information and Cooperation in Nuclear and Radiation Safety Matters with the nuclear regulatory body of various other countries.

(c) The design on nuclear power plants (NPPs) in India incorporates concept of defence in depth, several in-built safety features, and adopts the redundancy in safety systems. NPPs are operated with strict adherence to operational limits & set procedures. Therefore, probability of severe accident in NPP is very-very low. Department of Atomic Energy (DAE) has a very robust framework for management of nuclear emergency in the public domain. The preparedness and emergency response systems to safeguard the civil population living near atomic energy sites are mentioned below;

1) The infrastructure requirements, for management of nuclear emergency in public domain as specified by – Atomic Energy Regulatory Board (AERB) for emergency response functions, are well established and maintained in coordination with the Local, State and National Authority.

2) To minimize the consequences in public domain due to radioactive releases in the event of nuclear emergency, Emergency Planning Zones (EPZ), surrounding the NPP site boundary are identified at the planning stage itself. This is to ensure immediate precautionary actions and urgent protective actions in public domain in the event of an emergency.

3) Each NPP has Off-site Emergency Preparedness and Response Plan in which the roles and responsibilities of NPP operator, local authority, Crisis Management Group-DAE (CMG-DAE) are well specified.

4) The district and state wherein the NPP are located has District Disaster Management Plan and State Disaster Management Plan respectively, which are prepared in coordination with National Disaster Management Authority (NDMA) and includes the management of nuclear emergency situation around the NPP.

5) Various systems for large area radiation surveillance around the NPP aid in decision making on protective actions in public domain during the emergency situation are in place.

6) Periodic emergency exercises are jointly conducted by local authority, NPP operator, AERB and DAE in coordination with NDMA to test the Off-site Emergency preparedness and Response Plan and District Disaster Management Plan.

7) Various teams such as radiation emergency response team of DAE, local authorities, medical and para-medical team, State Disaster Response Force (SDRF), National Disaster Response Force (NDRF), Civic Volunteers are trained in handling any potential nuclear emergency situation.

8) A well-defined zoning system is followed, which includes an Exclusion Zone (1.5 km), a Sterilized Zone (up to 5 km), and an Emergency Planning Zone (up to 16 km) around each nuclear facility.

9) Nuclear Power Plants (NPPs) are sited, designed, constructed and operated in accordance with stringent regulatory and safety requirements stipulated by Atomic Energy Regulatory Board (AERB) and adherence to these is ensured throughout the lifetime of the plants. A defense-in-depth philosophy is followed in the design, construction and operation of all NPPs in India, which has the objectives of prevention of accidents.

Emergency preparedness and response plans have also been formulated as per requirements and guidance given by AERB to protect public in case of emergencies. These plans are tested periodically through exercises as well as revised periodically to be in line with the current requirements and situations.

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