International Atomic Energy Agency

GENERAL CONFERENCE

GC

GC(XVIII)/INF/149/Add.7
16 September 1974
GENERAL Distr.
Original: ENGLISH

Eighteenth regular session

ADVANCES IN THE APPLICATION OF NUCLEAR ENERGY FOR PEACEFUL PURPOSES

Information transmitted by South Africa

Note by the Director General

On 6 September the Director General received from South Africa material on the advances made in the year 1973-74 in applying nuclear energy for peaceful purposes. The material in question is reproduced below for the information of the General Conference.

NUCLEAR POWER

1. Probably the most significant development in the nuclear field in South Africa during the past year was the firm announcement by the Electricity Supply Commission of its intention to construct the country's first nuclear power station, Koeberg 'A', at Duinefontein near Cape Town. The station will be a twin pressurized water or boiling water reactor installation in the capacity range 800-1000 MW(e) per unit, the first unit being scheduled for operation in 1982 and the second in 1983 or 1984.

2. Drilling and seismic investigations at Duinefontein, as well as oceanographic studies of the physical characteristics in the vicinity,

covering seabed conditions and their effects on inlet structures, direction and velocity of currents, tidal characteristics, etc., were continued. Preliminary investigations to establish the permissible levels of concentration of radionuclides in liquid effluent discharged into the sea were completed and micrometeorological studies were carried out. These studies are being continued and refined.

3. A report on the likely installation pattern of nuclear power stations in South Africa by the year 2000 will be published towards the end of this year. This report will also contain information on unit generation costs, uranium and coal requirements, the dates of installation and the location of the nuclear power stations.

NUCLEAR LICENSING

4. With regard to the forthcoming programme for land-based nuclear power stations, the Licensing Branch of the Atomic Energy Board has established the safety criteria and is providing the necessary guidance to the Electricity Supply Commission and potential suppliers on matters relating to the safety requirements of such installations.

5. An agreement was concluded between the South African Government and the Government of the Federal Republic of Germany for the nuclear merchant ship Otto Hahn to visit South African ports. Licences prescribing the conditions for such visits will be issued by the Atomic Energy Board for specified periods, typically six months. A goodwill visit by the Otto Hahn to Cape Town was arranged for the first week in September 1974 and thereafter the ship visited Durban.

NUCLEAR MATERIALS

Uranium exploration

6. The last 12 months have been marked by an upsurge in the prospecting for uranium by both South African and overseas concerns. The currently available information on the Karoo Supergroup in the Prince Albert-Beaufort West-Fraserburg area in the Cape Province, however, does not at present permit an adequate assessment of the economic potentialities of this area to be made.

7. The success of the installation of four uranium standards, against which scintillation counters used by the mining industry in the exploration for uranium are being increasingly accurately calibrated, gave rise to the preparation of a further three thorium standards, a mixed uranium-thorium standard and one borehole simulation standard composed of uranium ore, as new standards for the calibration of spectrometers. A technique for determining the radon gas as tracer for underground uranium is under development.

Uranium extraction

8. Intensive research into improved processes and equipment for the extraction and recovery of uranium from low-grade ores and residue dumps is being done by the Atomic Energy Board in collaboration with the uranium mining industry in the fully integrated research facilities at the National Institute for Metallurgy; these facilities allow complete development projects on any uranium ore deposit to be undertaken. Projects are being undertaken which involve all aspects of the necessary research and development work for the exploitation of specific ore deposits, from preliminary

mineralogical and extraction tests, through laboratory and pilot-plant investigations to full-scale plant design and economic feasibility studies.

9. Considerable success was achieved with the development of a continuous ion exchange pilot plant for uranium recovery at one of the producing mines. This plant has been operating 24 hours per day, seven days per week, for the past two years. All the problems associated with the operation of this plant on filtered, but unclarified, solutions from the main uranium plant have been overcome and attention is now being given to investigating the suitability of the pilot plant for handling dilute slurries. Towards the end of the year the pilot plant was operated for protracted periods on a feed containing 10 per cent solids, and no problems were encountered. It is now anticipated that a very significant reduction in the capital cost of the solid/liquid separation operation will be realized by the use of this process and that the development of a very inexpensive process for the recovery of uranium from low-grade residue dumps will become possible.

10. Commercially available instrumentation for the control of the supply of sulphuric acid and manganese oxide to the leaching stage in uranium plants was found to be inadequate; the development of efficient instrumentation was consequently undertaken. After this instrumentation had been very successfully tested over several months on one full-scale plant, five other mines also ordered the equipment in order to benefit from the considerable saving in cost resulting from its use.

11. Much effort was also devoted to the application of ore preconcentration techniques such as gravity concentration, flotation and wet high-intensity magnetic separation, particularly in the context of uranium and gold

recovery from cyanidation tailings that have accumulated from the treatment of the Witwatersrand gold ores. Considerable progress was also made on the fundamental aspects of the acid and alkaline leaching of uranium ores and on various other aspects of uranium extraction and recovery, particularly from newly discovered deposits in Southern Africa.

FUEL DEVELOPMENT

12. In view of the possible use of solid solutions of uranium carbide in uranium monosulphide as fast reactor fuels, an investigation into the preparation, properties and behaviour of such solutions was undertaken. Problems were experienced in the preparation of this compound but these were overcome by the development of a new method whereby zinc sulphide is reacted with uranium in the form of powder, with subsequent removal of the zinc by evaporation. Subsequently it was shown that zinc sulphide will react with uranium monocarbide itself, and this discovery was the basis of an improved method for preparing solid solutions of the above-mentioned uranium compounds without the use of the expensive uranium metal. For the preparation of these materials on a larger scale, and their fabrication into dense pellets, a new glove-box facility, comprising eight interconnected glove boxes with a high-purity argon atmosphere, was constructed.

SOLVENT EXTRACTION FROM MOLTEN SALTS

13. Distribution studies of platinum metals between liquid metals and molten cyanide were continued and emphasis was placed on developing a separation method for rhodium, iridium, ruthenium and osmium. It was found that efficient

separation of these elements can be achieved using molten cyanide solutions containing a total concentration of up to 7% of these elements. Tests performed on an industrial concentrate of platinum metals showed that the process may have potential use on an industrial scale. A prominent feature of the process is the high separation factor with which certain pairs of platinum metals can be separated. This property was, for example, used as a basis for a fast and efficient radiochemical separation method of ^{105}Rh from neutron-irradiated ruthenium. Rhodium can similarly be purified of iridium impurity with a separation factor of more than 10^3 by selectively reducing rhodium with tin if nickel, which apparently prevents the reduction of iridium, is present in the system.

URANIUM ENRICHMENT

14. Activities in the field of uranium enrichment have advanced to the stage where, as a first step in the direction of a large-scale economic enrichment plant, the Government has decided to make funds available for the preparatory work with regard to the construction of a full-scale prototype stage for such a major plant. Feasibility studies are under way with a view to the erection of a large-scale plant in South Africa.

RESEARCH REACTOR

Reactor experiments

15. In the case of the 20-MW South African research reactor SAFARI-1, the following major activities were under way during the year:

(a) The cryogenic facility was used for the study of the effects of radiation-induced defects on the physical properties of

materials. This facility permits irradiation of small samples at temperatures down to 4.3°K. The irradiating flux can be adjusted so that either thermal or fast neutrons predominate, while the reactor gamma spectrum is shielded by lead. Alternatively, spent fuel may be used to provide gamma irradiation alone;

(b) Off-line control of the single-crystal neutron diffractometer was successfully achieved and was tested with an ammonium fluoride crystal of which the structure is well known. The implementation of on-line control progressed well and certain subsystems were tested. A start was made with inelastic scattering experiments with a view to determining the additional shielding required, and to point up certain other necessary features;

(c) A facility for studying the scattering of subthermal neutrons at very small angles was installed for the investigation of defect clusters formed during irradiation;

(d) An irradiation rig for testing the suitability of local stainless steel as a reactor constructional material was completed, and two locally designed capsules containing stainless steel samples were prepared for irradiation. A special lead cell containing a remote tensile-testing machine was constructed to evaluate the irradiated samples;

(e) A high-temperature irradiation rig for fission-gas release studies of fuel is being tested prior to installation;

(f) A rotating ore-irradiation rig was used for the activation of relatively large quantities of crushed ores for tracer studies in gold extraction, beach sand movement, etc.; and

(g) Various other facilities were in use, principally for isotope production, activation analysis and (n,γ) studies.

Isotope production

16. The extent of local isotope production in the reactor increased considerably during the last year as did the interest shown by potential users, particularly in the medical field. Three large lead-shielded hot cells, equipped with MA-II manipulators and lead-glass windows, were completed and commissioned. These cells are used for the production of ^{60}Co and ^{192}Ir; some 60 kCi of the former was produced in the form of 18-inch pencils destined for the Package Irradiation Plant.

17. Of the isotopes now produced locally, the most important is iodine-131 which, until recently, had been imported in bulk to the extent of approximately 2 Ci/annum and then locally subdivided for distribution. In contrast to this, the first 14 weeks of local manufacture resulted in the distribution of almost 6 Ci.

Neutron activation

18. Amongst other important uses to which the reactor was put was, naturally, that of neutron activation. In the field of neutron activation

analysis, two significant investigations dealt with the role of trace elements in dental pathology and in oesophageal cancer. The object of these studies was to determine the correlation of dietary deficiencies with the incidence of these clinical conditions.

RADIATION TECHNOLOGY

Wood plastics

19. In an investigation of wood-plastic composites produced by the cobalt-60 irradiation laboratory, studies were directed towards working out methods for decreasing the percentage of monomer in the final product without substantially affecting its attractive properties. Two possibilities were determined namely the use of denser pine species such as Pinus radiata and the modification of the method of impregnation to achieve a lower uptake. Present indications are that much lower loadings than previously thought possible can be achieved, with consequent cost-savings, without adversely affecting the quality of the product.

Radiation sterilization

20. The irradiator designed for the sterilization of medical products was operated on a semicommercial basis and was utilized mainly by manufacturers of disposable surgical equipment. Following a modest start, throughput increased at an exceptional rate and source augmentation took place on three occasions during 1973/74. The total source loading was increased to 180 kCi of ^{60}Co at the end of the period, and consideration is being given to increasing this to 380 kCi in the near future. (The

initial loading was 50 kCi). A wide range of products was handled including sutures, surgical gloves, syringes, urine bags, catheters, cannulae, disposable swabs, operation packs and various latex devices.

Food irradiation

21. In the field of food irradiation, technological studies on the radiation processing of subtropical fruits were continued. The top-priority project remained the extension of the shelflife of mangoes: an intensive study on the behaviour of irradiated fruit during and following simulated shipping has been launched. The results obtained were highly satisfactory and indicated that it would be feasible to ship irradiated mangoes to Europe by refrigerated boat and still leave them with sufficient shelflife at ambient temperature to enable them to be widely marketed. Irradiation inactivates the seed weevil, decreases the incidence of disease and retards the ripening process, without causing any adverse organoleptic changes.

22. In view of the importance of international clearances for free trade in irradiated mangoes the International Food Irradiation Project was asked to investigate the possibility of adding this product to the list of irradiated commodities being assayed for wholesomeness. Following a visit to South Africa by the Project Leader, and after an analysis had been carried out by the Scientific Programme Committee, mangoes were accepted for inclusion among the food items being studied.

23. Good progress was made toward the initiation of acceptability testing of a model product with a view to presenting a petition to the

Department of Health for the clearance of this product for general consumption. In this context, a particularly important breakthrough was made in obtaining commercial sponsorship for a potato-acceptability study. In terms of this sponsorship, the firm will supply 25 tonnes of potatoes to be used in trial marketing; in return, the feasibility of using stored, irradiated potatoes in the potato processing industry will be assessed.

HEALTH AND SAFETY

24. Health and safety continued to be a field of considerable investigation and a technique for determining the dispersion and dilution of airborne effluents, in which harmless inactive tracers are utilized, was developed and tested at Pelindaba. It is now being applied to conventional pollution at Richards Bay and will also be applied in the case of South Africa's first nuclear power station.

25. A study on radon hazards in uranium mining and processing, which is of special interest to the South African gold mining industry (in which uranium is mined together with gold) was carried out. This study indicated no increased incidence of lung cancer in South African gold/uranium mines. Furthermore, it shed light on the deficiencies in existing methods for evaluating individual exposures.

NUCLEAR TECHNIQUES

26. The practical application of nuclear techniques is arousing growing interest in non-nuclear circles. Attention continued to be given to X-ray

fluorimetry using radioisotope sources, and the technique was applied with great success to uranium analysis. Promising results were also achieved with the determination of slurry particle sizes and of the ash content of coal, while the investigation of ore mills by means of tracer techniques revealed unique possibilities. Methods for using tritium and deuterium were developed and applied to the study of water movement in soil and plants, as well as during evaporation, in practical drainage experiments at two different sites. Methods for the characterization of underground water bodies were developed and applied with success.

27. In the medical field, whole-body counters were in full-time use for medical diagnosis and research in all the teaching hospitals in the country. These counters are of immense value in the estimation of malabsorption studies. The diagnostic use of radio-immunoassays in South Africa is still amongst the foremost in the world. These tests are nowadays also conducted by a large number of medical practitioners outside the bigger hospitals. During the year human-growth hormone was completely purified and estimated by this method. Scientific articles were published on the purification method which, for the first time anywhere in the world, yielded an absolutely purified hormone which now permits the treatment of dwarfism at reasonable cost.

28. Research on liver cancer continues. With the collaboration of the Medical Research Center of Brookhaven National Laboratory a biochemical study on cancer made good progress, as did further studies on pellagra and the metabolism of tryptophan. The report of a diagnostic study, using radioisotopes, on a large number of patients with liver abscesses, was published in an international journal and evoked wide interest. This

study was shown to provide the best guide lines in the diagnosis and treatment of this condition.

29. Modern gamma cameras with on-line computers are now in use in the teaching hospitals; this technique greatly extends the clinical uses of radioisotopes, especially in kinetic studies of the vascular system and of the respiratory and renal organs.