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PROGRESS IN PEACEFUL APPLICATIONS OF NUCLEAR ENERGY DURING THE YEAR 1968-1969

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UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND

Advances in nuclear energy: 1968/69

INTRODUCTION

1. To equip the British nuclear industry to meet the increasing demands that will be made upon it at home and from abroad, the design resources of the various industrial organizations and the United Kingdom Atomic Energy Authority (UKAEA) are being concentrated into two design and construction companies, The Nuclear Power Group and British Nuclear Design and Construction Limited. These two companies are formed from firms of wide experience which cover the whole technological spectrum necessary to the successful design and construction of complete nuclear power stations, and are equipped to deal with all existing and future British reactor systems. Thus, effective competition within the United Kingdom will be retained along with a more efficient and economical integration of technological and industrial resources. It is also planned to create an independent nuclear fuel company from the UKAEA's fuel production organization. These new companies will continue to be supported by nuclear research and development establishments with a total staff of about 20 000. The Government believes that the new arrangements will facilitate the forging of industrial links abroad, now that nuclear power production is a commercial matter.

NUCLEAR POWER PROGRAMME

2. The proportion of electric power which is generated in the UK by nuclear power stations continues to increase. Wylfa, the ninth Mark I gas-cooled (MAGNOX) station in the first nuclear power programme, will come on power in the next few months. The reliability of these stations is impressive. After two or three years of operation, their annual load factors average upwards of 80%. Their monthly load factors are often much higher, sometimes exceeding 100% of designed output capacity.

3. The second nuclear power programme based on the Mark II advanced gas-cooled reactor (AGR) system is making good progress, with four stations totalling about 5000 MW(e) currently under construction at Dungeness 'B', Hartlepool, Hinkley Point 'B' and Hunterston 'B'. TheHartlepool station is being built within five miles of where nearly 200 000 people are living. This follows acceptance by the Minister of Power and the Secretary of State for Scotland of the advice of the Nuclear Safety Advisory Committee that the safety of a gas-cooled reactor in a prestressed concrete pressure vessel is such that it may be constructed and operated much nearer built-up areas than hitherto permitted

in the UK. In addition, the Central Electricity Generating Board have increased their assumption (for accountancy purposes) as to the life of AGR power stations from 20 to 25 years as a result of satisfactory experience of the Windscale AGR.

NUCLEAR FUEL SERVICES

4. The past year has seen a considerable expansion of the UKAEA's production and commercial activities. Fuel production for existing UK power reactors reached a peak, new oxide fuel manufacturing plant was brought into operation and additions were made to the UKAEA's reprocessing capacity.

5. Throughput of the Springfields uranium hexafluoride production plant has significantly increased. The new plant is now proved and is capable of meeting all requirements for feed material to the Capenhurst enrichment plant and in addition is being used increasingly for the conversion of overseas customers' uranium ore concentrate to uranium hexafluoride for subsequent enrichment. The new oxide fuel plants are producing fuel for the UK AGR programme and are being used to manufacture fuel for water reactors both at home and overseas. A fast reactor plutonium fuel fabrication plant is scheduled to be in production in 1970 to meet the fuel requirements of the prototype fast reactor at Dounreay.

6. A plant for the assembly of MAGNOX fuel under licence from UKAEA has been built and commissioned at Rotondella in Southern Italy by Combustibili Nucleari, a joint company formed by Somiren (E.N.I.) and UKAEA. The plant will produce fuel for the Latina reactor.

7. The new head-end plant at Windscale is now operational. This facility, in conjunction with the existing reprocessing plant, will be used to reprocess irradiated oxide fuels from reactors at home and overseas.

8. Substantial capacity has now been added to the Capenhurst enrichment plant as part of its programme of expansion to provide the necessary enriched uranium for AGR fuel. Development of the gas-centrifuge process for enriching uranium has been brought to the stage where the UK believes it can successfully be used on a production scale. The UK Government has therefore entered into negotiation with the Governments of the Federal Republic of Germany and of the Netherlands - where work on the centrifuge has also been going on - with a view to collaboration by the three countries in the establishment of uranium enrichment plants, using the centrifuge process, in Western Europe. Negotiations are proceeding and given their successful conclusion it is envisaged that two jointly-owned enrichment plants will be built - one in the UK, the other in the Netherlands. Thought is also being given to the ways in which other countries might be associated with the enterprise once it has been set up.

REACTOR DEVELOPMENT

9. Work continued during the year on the development of the Mark II AGR, and effort has been concentrated mainly on confirmation of fuel design. The Windscale AGR, which has now operated for over six years with an availability of nearly 85%, has been used extensively for testing fuel for the reactor power stations operated by the regional generating boards. In addition, there has been continued work aimed at the exploitation of the considerable development potential of the AGR system. This work has confirmed the economic advantages of AGR reactor designs using fuel in the form of graphite-coated particles; and a development programme has been initiated using low-enriched coated-particle fuel in graphite tubes cooled by helium.

10. Faulty operation of the water purification plant associated with the steam generating heavy water reactor (SGHWR) at Winfrith, which caused deposition of solids on the fuel elements, with consequent failure of the cladding material of some fuel elements, has now been rectified. Apart from the consequences of this malfunctioning of the water purification plant, SGHWR has performed very well and has generated almost 500 million units of electricity since it achieved full power in January 1968. Design studies have been completed for full-scale SGHWR stations which would use more highly rated fuel than that at present in

use at the Winfrith reactor. Experimental operation of certain fuel channels at Winfrith at these higher ratings has confirmed their suitability for full-scale use.

11. The Dounreay fast reactor has been used throughout the past 12 months as a fast-flux testing facility. Irradiation space in the reactor has been used by many countries for the irradiation testing of their fast reactor fuel elements. The UK fuel irradiation experience for prototype fast reactor (PFR) fuel elements is increasing steadily and gives confidence in the future for this reactor system. Experience with the handling of sodium and with the development of fast reactor components continues to grow at an increasing rate. The construction of the prototype fast reactor at Dounreay for the UKAEA was delayed owing to difficulties in welding the roof of the biological shield: this is a conventional engineering structure, and detailed changes in design and manufacture will prevent any recurrence of the problem in future reactors. While construction of the prototype reactor has been continuing, laboratory and irradiation experiments have confirmed the design and performance characteristics selected for the first fuel charge. Work has continued during the year on a series of fast reactor designs for full-scale generating stations based on PFR.

DESALINATION

12. The United Kingdom is ideally situated in having both nuclear power and desalination development programmes. This puts Britain in a special position with regard to the development of nuclear desalination techniques. During the year a British firm obtained the order for what will be by far the largest electrodialysis unit in the world. Research continues into the problems of various systems of desalination with the participation of UKAEA and various companies in this field.

MARINE PROPULSION

13. Work has continued on the burnable poison pressurized water reactor which might find particular application in ships. Government departments are carrying out economic studies of nuclear ships for a range of applications and powers. UKAEA, in conjunction with a ship-building firm, has studied in detail a scheme for a container ship of 40 000 shaft horse-power.

NUCLEAR RESEARCH

14. A reassessment of UKAEA's longer term research programme as a consequence of the achievement of economic nuclear power resulted in a reduction in and a change in emphasis of much of the work. The Harwell reactor BEPO was closed down in December 1968 after twenty years of valuable operation, and closure of the Dounreay materials testing reactor followed in May 1969.

15. The primary aim of the longer term research programme is to study the effects of irradiation and impurities on the mechanical, physical and chemical properties of materials of interest for the reactor and applied research programmes. Specific areas which have so far received attention include radiation-induced void formation in metals and structural changes in refractory ceramic oxides, as well as the effect of radiation on the reactivity of water and carbon dioxide, and the strength and cohesion of multiphase alloys and composites.

16. Increasing use is being made, especially by universities, of neutron beam equipment to study interatomic forces and atomic motions, magnetic structure and other atomic and physical properties. Notable progress has also been made in physical and chemical studies of all the types of nuclear reactions of importance in reactor technology.

17. The nuclear fusion research programme at Culham Laboratory continues to be organized and implemented with the advantage of a full exchange of information among the principal world laboratories engaged in this field. Over-all plasma confinement times continued to increase and show promise that the confinement needed for a fusion reactor can be realized.

18. During the year experiments on ZETA, the first major toroidal device for the containment of high temperature plasma, were brought to a successful conclusion; work has continued on two other closed-line devices, a small stellerator and a toroidal multipole. Valuable results are also being obtained on simpler open-ended systems such as the 8-metre thetatron and the magnetic mirror machines.

19. Advances in the densities, temperatures and containment times of plasma in all these devices have been recorded, as well as excellent progress in the basic understanding which is essential in order to extrapolate from the present-day experiments to fusion reactors, the technology for which is now being actively studied.

20. UKAEA have continued to exploit the use of radioactive isotopes and radiation in solving problems of importance to industry. The package irradiation plant at Wantage was increased in irradiation strength to meet the demands for sterilization of medical supplies and animal foods. Laboratory animal feeding studies designed to reveal any toxicity of irradiated fish were completed and similar toxicological studies were carried out on irradiated meat intended for pet food. Industrial interest is growing in the use of radiation for polymerization in situ of plastic-impregnated wood; and expertise in the electro-chemical field was successfully applied to several specific electroplating problems. Radioactive tracer techniques were applied to problems of water flow, conservation and supply, and to sediment movement in the sea and in estuaries.

21. The isotope-heated thermoelectric generator programme RIPPLE is nearing completion. All the prototype generators have performed exactly as predicted, powering off-shore marine lights and a navigational beacon; and a generator system has been developed which can be assembled to give generators of any power between 8 and 64 watts. An encapsulation plant for strontium-90 titanate is nearing completion.

INTERNATIONAL COLLABORATION

22. United Kingdom policy continues to be to collaborate to the full in the peaceful uses of atomic energy, both through international organizations such as the International Atomic Energy Agency, the European Nuclear Energy Agency and the European Community, with which the UK-EURATOM agreement has been extended, and bilaterally.

23. The United Kingdom has thus continued to support the Agency by the provision of voluntary financial contributions, material, experts, fellowship places, and consultants, and to participate fully in all its activities. The exchanges of information conducted by the Agency are regarded as of the greatest importance, as is the technical assistance afforded by the Agency. Of major importance to the safe and progressive expansion of the peaceful uses of nuclear energy is the Agency's safeguarding responsibility. The United Kingdom participates to the full in the relevant Agency studies and developments in this field, to which it brings considerable operational experience, while continuing research and development on procedures and methods relevant to the current expansion of the nuclear industry, and to the requirements of the Treaty on the Non-Proliferation of Nuclear Weapons.

24. During the year the UK Government signed a new agreement with the Government of Chile, and agreements with Finland and Japan came into force. A trilateral safeguards agreement with the Agency and Japan came into effect. In addition UKAEA now have agreements for collaboration with organizations in 18 countries.