Management of Radioactive Wastes from the Nuclear Fuel Cycle

The increased emphasis in many countries on the development and utilization of nuclear power is leading to an expansion of all sectors of the nuclear fuel cycle, giving rise to important policy issues and radioactive-waste management requirements. Consequently, the IAEA and the Nuclear Energy Agency of OECD felt that it would be timely to review the latest technology for the management of the radioactive wastes arising from nuclear-fuel cycle facilities, to identify where important advances have been made, and to indicate those areas where further technological development is needed.

Beginning in 1959, the IAEA, either by itself or jointly with OECD/NEA has held seven international symposia on the management of radioactive wastes. The last symposium, on the management of radioactive wastes from fuel reprocessing, was held jointly by the IAEA and OECD/NEA in Paris in November 1972. An objective of the 1976 symposium was to update the information presented at the previous symposia with the latest technological developments and thinking regarding the management and disposal of all categories of radioactive wastes. Consequently, although the scope of the symposium was rather broad, attention was focussed on operational experience and progress in unresolved areas of radioactive waste management.

The programme dealt primarily with the solidification of liquid radioactive wastes and disposal of the products, especially the high-level fission products and actinide-containing waste from fuel reprocessing. Other topics covered policy and planning, treatment of hulls and solvent, management of plutonium-contaminated waste, and removal of gaseous radionuclides.

The major topic of interest was the current state of the technology for the reduction and incorporation of the high-level radioactive liquid from fuel reprocessing into solid forms, such as calcines, glasses or ceramics, for safe interim storage and eventual disposal. The approaches to vitrification ranged from two stage processes that first produce a calcine, which then is incorporated into a glass melt, to processes which vitrify the concentrated high-level liquid waste in one step. A novel approach, being investigated at Eurochemic, is the incorporation of a high-level waste calcine into metal matrices.

One session was devoted to the evaluation of the solidified high-level radioactive waste products with respect to their resistance to thermal, radiation and chemical attack, and their mechanical stability. There was general agreement that calcines themselves were not a suitable disposal form and boro-silicate glasses appeared to be preferable to phosphate glasses. On the other hand, recent work being done at the Hahn-Meitner Institute indicates that glass ceramics have superior qualities for the fixation of fission-product radionuclides.

While several papers presented the results of accelerated radiation tests on vitrified samples, very little could be inferred regarding the long-term radiation effects on solidified high-level

waste products except that, so far, there is no indication of a serious stability problem. Merritt (Canada) presented favourable results from *in situ* testing of high-level radioactive waste which had been incorporated into nepheline-syenite glass blocks and buried in in the water table since 1960.

The presentations confirmed that many countries now are examining the possiblities of disposing of both the solidified high-level waste products and the longer-lived transuranic contaminated waste into suitable geologic structures. Papers were presented on current and proposed investigations with the objective of demonstrating the integrity of carefully selected radioactive-waste repository sites not only in salt formations but also in clay and crystalline rock formations. Platt (USA) examined the options and technologies for managing radioactive waste and pointed out that a discard, or throw-away, fuel cycle increases the plutonium content of the final waste product by at least sixty fold. Several papers reviewed the long-term hazards of actinide-(transuranic)containing waste fixed in a relatively insoluble matrix and confined in a suitable geologic repository. They all concluded that there was no incentive from a radioactive-waste management standpoint to removing the actinides from high-level waste for separate disposal. While there appeared to be a notable lack of enthusiasm among the participants towards partitioning the actinides from fission product waste, there was general agreement that the basic information required for suitable analyses should be developed.

Another major topic dealt with the latest developments for the conditioning of medium-level radioactive waste into concrete or bitumen forms. While it generally was agreed that both concrete and bitumen forms have their place, several presentations expressed a preference for bitumen because of the significantly smaller volume of the product along with its greater resistance to damage during handling. On the other hand, concrete is preferred in some countries because of the additional radiation shielding it provides and because of the fire hazard associated with the use of bitumen. On the basis of extensive tests, it was found that bituminization for the incorporation of spent ion-exchange resins is preferable to using concrete. Two papers dealt with recent developments in the incorporation of medium-level radioactive wastes into polymer-impregnated concrete and thermo-setting resins, respectively.

Four papers covered developments in Belgium, France, Federal Republic of Germany and Japan on the removal of the gaseous radionuclides, iodine, tritium and krypton, from process off-gases. While several approaches were being investigated for the removal of tritium and iodine, it appeared that all favoured separating krypton by means of a cryogenic distillation process after appropriate pretreatment of the process feed, because cryogenic distillation is used for the commercial production of the stable rare gases and is a proven technology.

With respect to low-level radioactive wastes, Van der Voorde (Belgium) described an interesting high-temperature (1500–1600°C) incineration process under development at Mol. Other papers described a laundry detergent developed in Japan that decomposes at water evaporation temperatures, and process innovations and improvements in the effluent waste-water treatment plant for the Bhabha Atomic Research Centre, India. The Indians also presented their experience in handling hulls from chopped-leached fuels. Healey (UK) discussed the solvent degradation investigations at AERE, Harwell.

Dyer (USA) discussed the results of surveys by submersibles of three U.S. ocean dumping sites and Sakata (Japan) presented the Japanese efforts for suitable conditions and high-

integrity packaging for the sea dumping of radioactive wastes. Two papers were given on the operational experience and condition of three U.S. radioactive waste burial grounds. Bardet (France) reviewed seven years experience and operating procedures for burying radioactive waste at Cap la Hague.

The presentations at the symposium indicated that considerable progress has been made in the development of waste management technology. Furthermore, it appears that the technology exists for the safe management, handling and disposal of all nuclear wastes generated during the various operations involving the nuclear fuel cycle. However, much of the technology still remains in the developmental stage. A great deal remains to be done in working out the engineering and design details, and adapting the technology to actual operating conditions and controls.

One can conclude that expanding nuclear power programmes will have available, when and where required, demonstrated technology for managing the radioactive wastes from all sectors of the nuclear fuel cycle. However, the authorities of national nuclear programmes must provide increased attention and support during the next five years to those areas where the technology remains to be demonstrated on a practical basis.

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The symposium was attended by more than 130 participants from 29 countries and the FAO, WHO, ECE and UNEP.

Development of Nuclear-based Techniques for the Measurement, Detection and Control of Environmental Pollution

Rapid industrialization and urbanization have brought about drastic changes in the environment and often leave in their wake a host of new pollutants that may pose serious immediate or long-term health hazards. There is an urgent need to apply scientific knowledge to detect such harmful pollutants and to track their movement in the environment.

The main purpose of the meeting was to identify the role of nuclear techniques in the solution of pollution problems. Topics covered included analysis of air particulates, activation analysis of water pollutants, X-ray fluorescence techniques, and tracer technology. In comparison to a similar symposium on the use of nuclear techniques for environment pollution studies held in October 1970, which dealt mostly with the use of neutron activation analysis and radioactive tracer techniques, the present meeting reflected the advances of X-ray fluorescence, electron-capture gas chromatography, and charged-particle induced analytical methods in trace analysis. A more selective approach in the choice of tracer techniques for investigating a particular pollution problem became apparent during the meeting.