HEALTH AND ENVIRONMENTAL IMPACTS OF REPROCESSING IN INDIA

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Abstract

India has at present an operating plant for reprocessing spent fuel located at Tarapur on the west coast of India. The plant has a capacity of 100 t/y of spent fuel. This report gives and example of the evaluation of health and environmental aspects of a reprocessing plant.

Introduction

India has established full-fledged nuclear fuel cycle facilities in support of its civilian nuclear power programme. These are being further expanded in stages with the objective of meeting the additional requirements for the 10,000 MW(e) installed capacity targeted to be achieved by the turn of the century. In view of its limited resources of natural uranium the programme envisages plutonium recycle in thermal as well as fast reactors and the utilization of its vast resources of thorium in ^{233}U fuelled breeders in the long run. Reprocessing and recycle forms, therefore, a key element in India's nuclear power programme.

India has presently an operating plant for reprocessing spent fuel located at Tarapur on the west coast of India approximately 100 km from Bombay. This plant has a capacity of 100 t/y of spent fuel. Another plant with similar capacity is being built at Kalpakkam about 100 km from the city of Madras in south India, and is expected to go into operation in 1996. Both these plants will essentially reprocess spent CANDU natural uranium fuel irradiated to about 6000 Mwd/te and in practice cooled for 3 - 5 years. This cooling time enables the circumventing of a number of process-related and radiological safety problems namely transporting spent fuel in dry condition without any forced cooling, absence of troublesome fission products such as ^{95}Zr-^{95}Nb and ^{106}Ru, less cooling requirements for the high active liquid waste and the vitrified glass canisters and lower worker and public doses. In India it is preferred to co-locate reprocessing and associated waste management facilities including recycle fuel fabrication plants at the same site as that of a nuclear power station since this approach considerably reduces transportation problems and costs and reduces risks in the public domain.

The reprocessing plant also can thus take advantage of the 1.6 km exclusion zone that is presently mandatory for a nuclear power plant in India. The reprocessing plant also incorporates conversion and calcination facilities for the conversion of uranyl nitrate and plutonium nitrate solutions to their oxide forms. The plant employs a chop-leach head-end and the conventional Purex process with modifications based on experience. The future plants would incorporate redundant lines of production, remote systems technology for maintenance and intervention of process equipment and optimised lay out for servicing and repair.

Environmental safety considerations and impact assessment

Environmental safety has received considerable emphasis and has top priority in the Indian nuclear programme. This is true of reprocessing as well. It must be stressed that in terms of likely accidents and their consequences the reprocessing plant is more benign as compared to a nuclear power reactor on a number of considerations such as considerably lower potential energy available for causing a dispersal of radio-active material, absence of volatile or gaseous fission product species such as ^{131}I and short lived fission gases and larger time constants for energy transients. The operating temperatures and pressures are also much lower; in fact the process systems are operated under negative pressure. On the other hand the reprocessing plant handles highly reactive and corrosive solutions of high specific activity and presents a different and complex problem of containment as compared to a power reactor although the same principle of defence in depth and multiple barriers is followed in the design and operation of such plants.

Being chemical plants, problems similar to a chemical plant can also exist but the stringent requirements imposed for the containment of radioactivity automatically reduces chemical pollution hazards.

The principal dose limit of 1 mSv/y for a member of the critical group in the public domain is followed in the design and operation of nuclear facilities in India. For co-located facilities this limit is inclusive of future facilities and expansions as well. In practice only 0.5 - 0.8 mSv/y is utilized for planning purposes. This is further apportioned among the various facilities operating and planned at the site, and further among the atmospheric, aquatic and terrestrial routes and also for specific radio-nuclides depending on the technical characteristics of the installation taking into account all significant pathways of exposure. The ALARA principle is also applied in arriving at these figures.

Based on these concepts a three-tier system of regulatory control and compliance is employed for radiological surveillance of effluents and the resulting exposure in the public domain arising from nuclear operations:

(I) discharge criteria are specified for each plant in the form of Technical Specifications for plant operations
(ii) all effluents before they are discharged from the plant are sampled and monitored at the source to ensure that discharge criteria are being met and
(iii) an independent means of monitoring the environment by organizing and conducting a detailed environmental monitoring programme is established.

These detailed measurements are carried out by the Environmental Radiological Laboratory located at each of the main sites in the country and operated by the Health Physics Division of the Bhabha Atomic Research Centre.

The primary aim of the environmental monitoring programme is to demonstrate compliance with the radiation exposure limits set for members of the public. This requires detailed measurements of radio-activity content in a number of environmental matrices. The samples are selected on the basis of potential pathways of exposure. The number and type of samples and sampling frequency can be site-specific depending on the nature of the operations, utilization of the local environment, existence of population clusters etc. A Quality Assurance Programme in which results of selected measurements are compared with international standards such as those of WHO, IRC and the IAEA, ensure the quality of measurement and the data. Although the primary emphasis is on samples that are relevant directly to the estimate of dose such as drinking water, edible food items, air, etc., a number of other samples are also assayed for radio-activity and used as trend indicators and sensitive indicators or markers. Examples of the former are sea water, sediment and the latter, goat's thyroid which concentrates the radio-nuclide ^{131}I to a great extent, if present in the environment.

Presently a reprocessing plant will be designed and operated so that the exposure for a member of the public will not exceed 0.03 mSv/y. The present experience shows that environmental releases are small and easily controlled to meet the above criteria without any difficulty.

Segregation of liquid effluents and dedicated treatment plants for treating plant effluents such as evaporator condensates, fuel storage pond ion exchange regenerant effluents as well as alternate methods for reducing effluent generation such as disposable cation exchange beds etc. have resulted in very small effluent discharge values for the Indian reprocessing plants. Ten year (1981 - 1990) annual average figures for the reprocessing plant at Tarapur has been as follows:

Liquids:	Alpha: 80 mCi/y (3 GBq/y)	Beta: 4.0 Ci/y (150 GBq/y)
Gaseous:	Alpha: 250 μCi/y (10 MBq/y)	Beta: 13.5 mCi/y (0.5 GBq/y)

Studies have also been conducted on the behaviour and release of ^{3}H and ^{129}I and to a limited extent ^{14}C.

The observations are as follows:

HTO: 25 - 35% of the inventory is released to the environment out of which 20 - 30% is in liquid effluent mainly in the final condensate from the evaporators. The remainder is estimated to be present in zircalloy cladding.

^{129}I: 10% of the inventory is released out of which 8% is released through stack mostly during dissolution and 2% in liquid effluent.

^{14}C: limited measurements indicate 10% of the inventory is released mostly in gaseous effluent with little in liquid effluent.

The dose to a member of the public in the critical group from the atmospheric and aqueous effluents including Kr^{85}, I^{129}, HTO, the fission products and the actinides is estimated to be less than $10\mu Sv/y$.

Since the Pressurized Heavy Water Reactors also release ^{14}C and HTO it is seen that the contribution from the associated reprocessing plants is less than that from a nuclear station of this type which is less than $10\mu Sv/y$ from both atmospheric and aquatic releases.

In so far as non-radiological pollutants are concerned, the emissions must conform to national pollution control standards.