

OVERVIEW

The behaviour of radionuclides in sodium loops and reactor systems has been extensively studied over the past two or three decades in support of the safe operation of LMFBRs. The studies, which are reported and discussed in this review, have shown that in common with other reactor designs the production of radionuclides in LMFBRs operating with mixed oxide fuel contained in Type 300 stainless steel cladding is by activation of the cover-gas, the coolant, core components and fission processes in the fuel. The coolant transports radionuclides away from the core and increased activity levels can occur in regions such as the cover-gas, the intermediate heat-exchangers and pumps.

The review indicates that after plant shut-down prior activation of the cover-gas and the sodium coolant should not significantly affect activity levels once ^{24}Na has been allowed to decay. Reactor experience indicates that Xe and Kr from tramp fuel or failed pins can be effectively removed by carbon beds and delay tanks respectively, and the longer half-life ^{85}Kr can be safely vented to atmosphere. Contaminants in the sodium such as ^{65}Zn , are known to present problems however, and the chemical behaviour of this element in sodium systems is discussed and methods for its removal are identified.

The behaviour of the long half-life corrosion products ^{58}Co , ^{60}Co and ^{54}Mn has been extensively reviewed and the general conclusion is that the radioactive corrosion products ^{54}Mn , and to a lesser extent, ^{58}Co and ^{60}Co , are, in the absence of failed pins, the main cause of contamination of LMFBR components. The mechanisms by which these isotopes are released and deposited in sodium systems have been studied in experimental loops and models describing their mass-transfer behaviour and codes, to estimate levels of contamination, have been obtained from the results. Measurements on reactor systems, to validate the codes, are now in progress, and so far it seems that the deposition behaviour of ^{54}Mn on heat-exchanger pipework can be estimated with some degree of certainty. However, the behaviour of ^{60}Co is less clear and in certain reactors it appears that this isotope may be retained in the core. It is concluded more work is needed to predict more accurately, the deposition behaviour of both isotopes in pumps and cold traps.

In those situations when the reactor is operating with failed pins the major radionuclides of concern are the isotopes ^{134}Cs and the long half-life (30 years) ^{137}Cs . The review highlights the fact that cesium is completely miscible in sodium and its high volatility means that it can combine with sodium aerosols in the cover-gas. Its under-sodium behaviour is characterized by thermodynamic partitioning between the steel and the coolant and loop experiments have indicated that it has an affinity for oxide films such as sodium chromite (NaCrO_2). The removal of cesium from the primary coolant by carbonaceous materials, such as reticulated vitreous carbon (RVC), has been demonstrated on operating reactors and although, as yet, no proper model exists to describe cesium behaviour in the reactor coolant and gas phase environment, techniques are available for controlling cesium levels in operating reactors.

The complex behaviour of tritium in LMFBRs is also reviewed and it is shown that tritium produced by ternary fission in the fuel of LMFBRs diffuses through cladding steels into the primary sodium. From there it permeates through constructional steels and eventually equilibrates with the secondary sodium, the sodium in the decay heat removal systems, the water-steam circuits, the argon cover-gas and the nitrogen blankets of the outer containment vessels and the cold-trap cells. It also co-crystallizes with sodium hydride in the primary and secondary circuit cold-traps to form sodium tritide. Results obtained from models which describe these various phenomena indicate that differences exist between model predictions and measured tritium values obtained from various reactor systems. However, work undertaken on Phenix, suggests that such differences can be reduced if improved source term values are used in the mass-balance equations and note is taken of the fact that co-crystallization in cold traps may remove higher levels of tritium from the sodium.

Other sections of the review deal with the measurement of radioactivity levels in LMFBRs and the development of techniques for the removal of the long half-life radionuclides (^{54}Mn , ^{65}Zn , ^{137}Cs) from the sodium coolant. Areas for further work are also identified.