RADIOACTIVE MATERIAL TRANSPORT IN FLOWING SODIUM SYSTEMS


Battelle-Northwest Laboratories, Richland, Washington

In a pumped sodium-cooled reactor, material will be removed from the fuel cladding by the corrosive action of the flowing sodium. Previous work has shown that stainless steel corrosion rates are low enough to permit operation to about 1200°F. (1) Much theoretical and experimental analysis of this corrosion process has been reported in the literature. (2, 3, 4)

Less attention, however, has been given to the problem of release and transport of radioactive materials in flowing sodium. Several attempts have been made (5, 6) to define the magnitude of the radiation levels arising from deposited activated corrosion products and fission products; they have been limited by the fact that the estimates were based on questionable assumptions of radioactive material deposition in the out-of-core areas.

Some experimental work has been done on the transport and deposition of activated corrosion products in flowing sodium (7). Earlier Battelle-Northwest work has been reported previously. (8, 9, 10) This paper will give a summary of the work and the latest conclusions to be drawn from it. The conclusions, stated briefly, are:

1. Fluid boundary-layer resistance to deposition of species exists for many isotopes, and under a broad range of conditions.
2. Deposited activity can either release from the deposition site and migrate through the loop, or diffuse into the base metal.
3. Deposited corrosion product activity can create reactor maintenance problems.
4. A great deal of work needs to be done before the release, transport and deposition of species is understood.
A schematic of the Radioisotope Transport Loop (RTL) where much of this study was conducted, is shown in Figure 1. More details on the loop, the specimens, and the counting techniques have been given previously.\(^{(6,9)}\)

**BOUNDARY LAYER RESISTANCE TO DEPOSITION**

A schematic description of deposition of species in and near flow perturbations is given in Figure 2. Chemical changes in the depositing species can still occur; however, if changes in deposition rate at flow perturbations are observed, the boundary-layer diffusional resistance can control the local deposition process.

The RTL was equipped with several changes in pipe diameter in hot and cold leg. Deposition of all three isotopes, \(^{51}\text{Cr}\), \(^{60}\text{Co}\), \(^{54}\text{Mn}\), in this area was sensitive to the flow perturbation, as shown in Figures 3 and 4. A plot of deposition vs Reynolds Number is given in Figure 5. This shows that \(^{60}\text{Co}\) seems to be the most sensitive to the reduction in boundary layer thickness. Perhaps this fact is related to the chemical nature of the species in sodium, as both Cr and Mn are relatively strong oxide formers, and Co is not. Information on the deposition behavior of nickel in this situation would be welcome.

Figure 6 shows similar deposition tendencies for \(^{51}\text{Cr}\) and \(^{60}\text{Co}\) in the RTL cold leg.

A small loop (50 grams of sodium) was operated isothermally for several days at 375°F with fission products in the sodium. The fission products were injected by recoil into sodium from irradiated enriched uranium foil; this sodium was then poured into the loop. The distribution of isotopes around the loop was fairly uniform except near the flow perturbation (the pipe was flattened) where large increases were observed in the amount of all isotopes. This is shown in Figure 7.

**Conclusions:** Deposition of all isotopes seems to be enhanced by reduced fluid boundary layer thickness under widely varied conditions. This phenomenon may be partly responsible for the increased deposition of species in reactor and loop cold traps. Any scheme proposed to trap out corrosion and fission products should incorporate a device for promoting turbulence.

**ACTIVITY MIGRATION**

The distribution of isotopes in the RTL makes it obvious that the hot-to-cold leg migration associated with the corrosion process takes place at different rates for different isotopes;