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SUMMARY

DISTRIBUTION OF FISSION PRODUCTS IN AN LMFBR

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Distribution of Fission Products in EBR-II Reactor Systems

SUMMARY

The overall distribution of fission products released from experimental subassemblies containing breached fuel elements has been determined in the fuel and throughout the EBR-II primary and secondary reactor systems. Identification of the fission products released to the primary sodium and location of areas of concentration was important in anticipating radioactive species and levels of deposited fission and activation products on components removed from the primary tank for maintenance and repair. The results of extensive radioanalytical measurements on the fuel, fuel cladding, primary sodium and cover gas system, secondary sodium and cover gas system and steam system are summarized.

Distribution of Fission Products in EBR-II Fuel

1. The axial distribution of fission products in EBR-II fuel was studied by gamma-scanning fuel elements at different burnups (3-10 a/o) and observing the axial distribution of the radioactive fission products. The only fission product found to migrate in the fuel up to 10 a/o burnup was ^{137}Cs. ^{131}I activity was expected to migrate in the fuel but the radioactivity decayed to low levels before gamma-scanning. The ^{137}Cs activity was concentrated in the bond sodium above the fuel matrix and to a lesser extent at the bottom of the fuel element.

2. The radial distribution of fission products across EBR-II fuel was determined by drilling five 0.05 cm diameter holes with an electrical discharge electrode across the diameter of a 0.33 cm diameter fuel element section about 0.65 cm length. ^{137}Cs activity was about four times more concentrated in the fuel drilled from the outside hole relative to the hole in the center of the fuel section.

Distribution of Fission Products in the Primary Sodium

The major fission products found in the EBR-II primary sodium after (~ 2 days) a fission product release are ^{137}Cs, ^{136}Cs, ^{134}Cs, ^{133}I, ^{131}I, ^{140}Ba-La, ^{89}Sr, ^{90}Sr-Y, ^{154}Eu, and ^{155}Eu. However, the fission product activity is reduced quite rapidly (within 3 days) either by deposition on surfaces, cold trapping, segregation to cooler areas, radioactive decay, or in the case of radiocesium, removed by the reticulated-vitreous carbon trap. The major radioactive activation and fission product activities in the EBR-II primary sodium after decay of ^{24}Na are summarized below.

Fission Product	Activity Range Bq/gm	Activation Product	Activity Bq/g
^{137}Cs	100-7000	^{22}Na	4800
^{134}Cs	50-900	^{113m}Sn-In	1700
^{90}Sr	1-8	^{125}Sb	275
^{89}Sr	1-6	^{54}Mn	110
^{131}I	1-4300	^{210}Po (α-activity)	0.3-1.3
^{239}Pu (α-activity)	0-0.08		
^{3}H	Up to 50,000		

Fission Products Found in Primary Cover Gas

The only activities identified in the EBR-II cover gas are tritium and the radioactive fission gas isotopes of Xenon and Krypton. The ^{133}Xe activity has been as high as 10 μCi/ml (3.7×10^5 Bq/ml) just after a fission gas release, but along with the ^{85}Kr activity is essentially quantitatively removed by the Cover Gas Cleanup System.

Fission Products Found in Secondary Sodium and Cover Gas Systems

The only fission product found in the secondary system of EBR-II is tritium. Tritium diffuses through the walls of the primary intermediate heat exchanger into the secondary sodium system. The secondary cold trap removes most of the tritium activity in the secondary sodium.

Tritium Distribution in EBR-II Facilities - ±1982

Tritium is a ternary fission product generated in the fuel which escapes from the fuel matrix and diffuses through the cladding to the primary sodium. Greater than 90% of the tritium generated is transferred from the fuel to other systems as shown in Figure 1. The concentration of tritium in the different systems is shown in Figure 2. Greater than 90% of the tritium generated is taken up by the primary cold trap.

Fission and Activation Products Found on the Surfaces of Major Components Removed from the Primary Sodium

The major activities found on surfaces of components removed from the primary sodium are ^{90}Sr-Y and ^{137}Cs. Minor quantities of ^{134}Cs, ^{58}Co, ^{60}Co, ^{51}Cr, ^{54}Mn, ^{155}Eu, ^{113}Sn-In, ^{131}I, and ^{182}Ta are found on most surfaces. Trace quantities of ^{234}U, ^{239}Pu, ^{241}Am, and ^{210}Po alpha activities have been identified on certain surfaces.

Fission Products Found on Cladding Surfaces of Breached Elements

When a subassembly containing a breached element is identified as a "leaker" by a Xe-tag technique, the subassebmly is transferred to the Hot Fuel Examination Facility (adjacent to EBR-II) where identification of the breached fuel element(s) is attempted by several nondestructive-postirradiation examinations. One method employs wiping each element with filter paper or cloth smears which are analyzed for radioactive fission product content. Fission products released by the breached element adhere to the stainless steel cladding at the point of breach and just above the breach which are picked up by the smear. Elements adjacent to the breach are contaminated by the fission products which impinge on the stainless steel cladding just opposite the breach. The high pressure in the fuel element plenum when suddenly released through a small breach forces bond sodium containing fission products across the primary sodium coolant flow and fission products which are only partially soluble in sodium, i.e., Sr, Eu, Ba, adhere to the cladding of the element directly in the path of the fission gas jet. The presence of uranium or plutonium on the smears taken from around the breach or on cladding surfaces adjacent to the breach is indicative of a large breach.

Anticipated Fission Products Released to the Environment Under Accident Conditions

EBR-II is a pot-type LMFBR which contains $\sim 3.25 \times 10^5$ l (86,000 gal) of sodium. All fission products generated in an accident situation (element meltdown or partial core meltdown) which are soluble in sodium are expected to remain in the sodium. The short-lived daughters (^{88}Rb, ^{89}Rb, ^{138}Cs, etc.) of fission gas precursors are expected to be the greatest source of fission products released to the containment building, apart from the fission gases. Initially, fission gas Xe and Kr will be the greatest activity in the cover gas and will be the source of activity leaking into the containment building. With the Cover Gas Cleanup System operating normally, $\sim$ 10 ft^3/min (145 l/min), activity in the cover gas is reduced by more than a factor of 2 every hour.

^{131}I, ^{137}Cs, ^{90}Sr, U, and ^{239}Pu will not be released and will remain in the primary sodium tank under accident conditions.

TRITIUM DISTRIBUTION

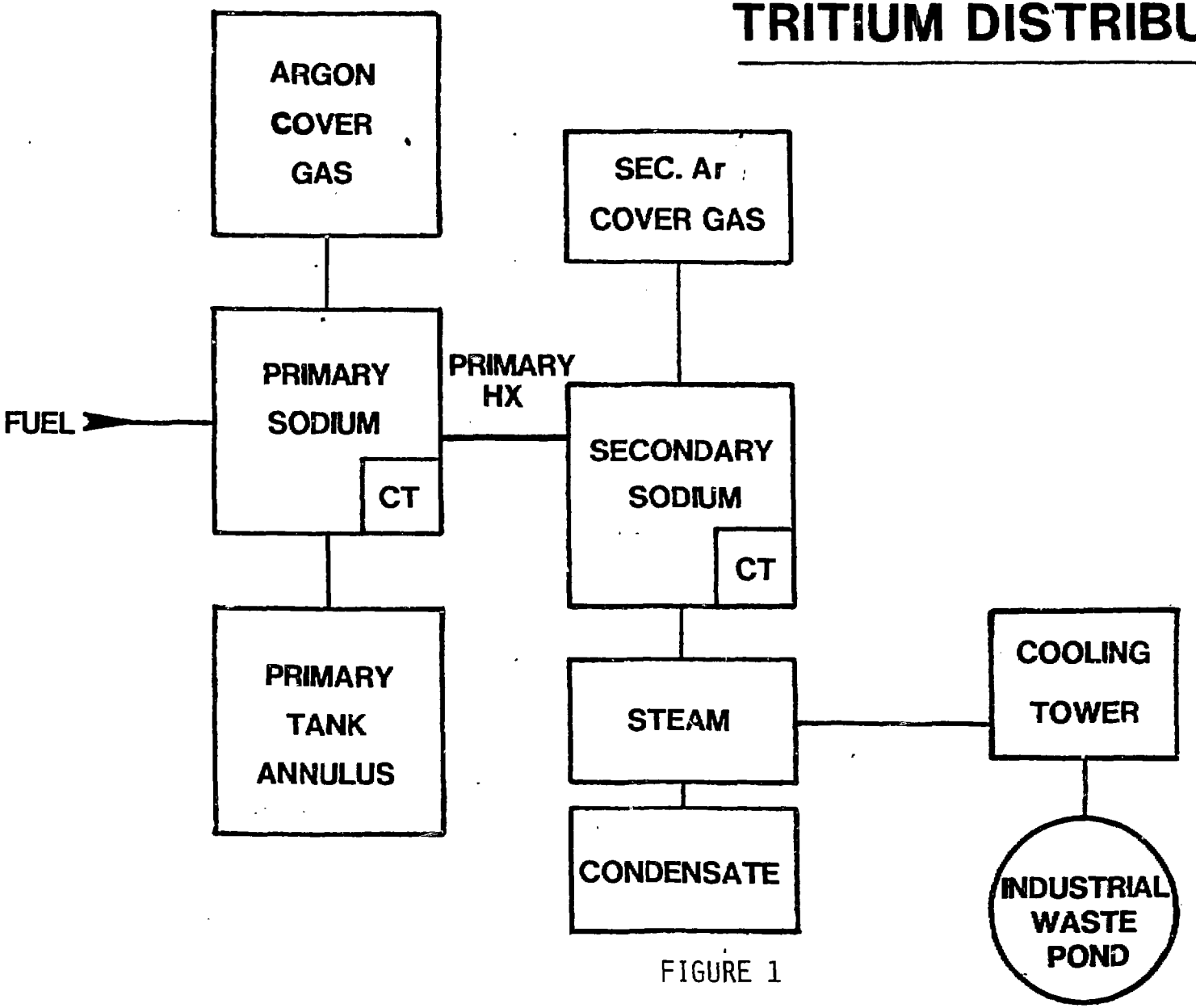

FIGURE 1

TRITIUM DISTRIBUTION
EBR-II FACILITIES 1982

Pri Na	—	475 nCi/g
Pri Ar	—	475 pCi/mL
Pri Tank Annulus	—	53 pCi/L
Shield Cooling Air	—	13 pCi/L
Sec Na	—	30 nCi/g
Sec Ar	—	5 pCi/mL
Steam Condensate	—	48 pCi/mL
Cooling Tower H_2O	—	< 4 pCi/mL
Industrial Waste Pond	—	< 4pCi/mL
Drinking Water	—	< 4 pCi/mL

FIGURE 2